Proceedings of the 16th International Symposium on Logistics (ISL 2011)

Rebuilding Supply Chains for a Globalised World

Berlin, Germany – 10-13 July 2011

Organized by

Nottingham University Business School
The new language of business

Edited by K S Pawar & H Rogers

www.isl21.net

Organised by:

The Centre for Concurrent Enterprise is a leading international centre for research in the fields of product/service design, concurrent and virtual enterprising, logistics, supply chain and related subfields. CCE conducts internationally leading research through collaborative projects, working with leading companies and universities across the globe. CCE has a successful track record and experience in many national and international, multi-disciplinary, industrially applied research projects. Topics have ranged from requirements engineering, electronic commerce, assessment and benchmarking for concurrent engineering, collaborative new product development, product-service systems, service and experience design, collaborative innovation, knowledge management, performance measurement, outsourcing and international contextualization of supply chains. The centre's staff co-organise two annual international conferences and publish the conference proceedings.

Website: www.isl21.net – managed by The University of Nottingham, Nottingham, UK and Clevercherry.Com.

Front cover: Brandenburg Gate, Berlin, Germany

ISBN: 978 085358 278 6

Published by: Centre for Concurrent Enterprise
Nottingham University Business School
Jubilee Campus
Wollaton Road
Nottingham, NG8 1BB
UK

Edited by: K S Pawar & H Rogers

Prepared by: A Parrett

ORGANIZING COMMITTEE

Symposium Chair
Prof. Kulwant S. Pawar
Centre for Concurrent Enterprise
Nottingham University Business School
University of Nottingham
Nottingham NG8 1BB, UK
Phone: +44 (0) 115 951 4029
Kul.Pawar@nottingham.ac.uk

Programme Co-Chair
Dr Helen Rogers
Wissenschaftliche Mitarbeiterin in
Supply Chain Management
Erlangen-Nürnberg University
Nürnberg D-90403
Tel.: +49 (0) 911/5302-444
Fax: +49 (0) 911/5302-460
Helen.Rogers@wiso.uni-erlangen.de
and Visiting Research Fellow
Nottingham University Business School
University of Nottingham
Nottingham NG8 1BB, UK
Phone: +44 (0)115 951 4011
Fax: +44 (0)115 846 7855
H.Rogers@nottingham.ac.uk

Programme Co-Chair
Prof. Chandra S Lalwani
Business School
University of Hull
University of Hull Logistics Institute
Hull, HU6 7RX, UK
Phone: +44 (0) 148 246 3049
c.s.Lalwani@hull.ac.uk

Symposium Administration
Mrs Alison Parrett
Centre for Concurrent Enterprise
Nottingham University Business School
University of Nottingham
Nottingham NG8 1BB, UK
Phone: +44 (0)115 951 4011
Fax: +44 (0)115 846 7855
Alison.Parrett@nottingham.ac.uk

INTERNATIONAL ADVISORY COMMITTEE

Prof. M Abrahamsson, Linköping University, Sweden

Prof. R Banomyong, Thammasat University, Thailand

Prof. D Bennett, Aston University, UK

Associate Prof. B Çatay, Sabanci University, Turkey

Prof. Y Chang, Korea Aerospace University, Korea

Dr P Childerhouse, University of Waikato, New Zealand

Prof. M Christopher, Cranfield University, UK

Dr A Coronado Mondragon, Holloway University of London, UK

Dr S Dani, Loughborough University Business School, UK

Dr A C J de Haan, Tilburg University, The Netherlands

Dr M Francis, Newport Business School, UK

Dr J Griffiths, Birmingham City University, Birmingham, UK

Dr S Harding, Birmingham City University, Birmingham, UK

Dr J Havenga, University of Stellenbosch, South Africa

Prof. M Y Jaber, Ryerson University, Canada

Prof. S Kara, University of New South Wales, Australia

Prof. Y Karasawa, Seijoh University, Japan

Prof. Y H Lee, Hanyang University, Korea

Assit. Prof. T T C Lirn, National Taiwan Ocean University, Taiwan

Prof. Tadayuki Masui, Musashi Inst. of Tech., Japan

Mr P McCullen, University of Brighton, UK

Prof. U Menon, Calpoly, California, USA

Prof. Emeritus M Miyazaki, Tohoku Uni., Japan

Prof. M Muffatto, University of Padua, Italy

Prof. M M Naim, Cardiff University, UK

Dr M Pallot, ESoCE, France

Dr A Potter, Cardiff University, UK

Prof. S Rahman, RMIT University, Australia

Prof. J Reese, University of Lüneburg, Germany

Dr J Riedel, University of Nottingham, UK

Dr H Rogers, Erlangen-Nürnberg University, Germany

Dr I Sadler, Victoria University, Australia

Prof. J Schumacher, Fachhochschule Vorarlberg, Austria

Prof. J Shah, IIMB, Bangalore, India

Prof. M Sugawara, Iwate Prefectural University, Japan

Prof. C Tang, UCLA, USA

Prof. K-D Thoben, BIBA, Germany

Dr N Tipi, Huddersfield University, UK

Prof. K Wakabayshi, Nihon University, Japan

Prof. J Walters, University of Johannesburg, South Africa

Prof. M Yu, Tsinghua University, China

Prof. X Zhao, Tsinghua University, China

INTRODUCTION

We would like to welcome our friends and colleagues to the annual International Symposium on Logistics (16th ISL). It is 18 years since the first symposium on Logistics was held in Nottingham in 1993 and is now considered as the premier international event in the field of Logistics and Supply Chain Management. As always many members of the ISL community look forward to meeting, sharing and exchanging their research ideas and results in both a formal and informal setting which the symposium provides. The ISL series continues to grow in strength and stature in terms of contributions made by the participants to the field of Logistics and Supply Chain Management. Similarly, the concept of alternating the symposium every year between Europe and the rest of the World is now well established. To date this event has successfully been held nine times in Europe (Nottingham, UK 1993 and 1995, Padua, Italy 1997, Florence, Italy 1999, Salzburg, Austria 2001, Seville, Spain 2003, Lisbon, Portugal 2005, Budapest, Hungary 2007, Istanbul, Turkey 2009)) and five times outside Europe (Iwate, Japan 2000, Melbourne, Australia 2002, Bangalore, India 2004, Beijing, China 2006 and Bangkok, Thailand 2008, Kuala-Lumpur 2010). This year's event in Berlin, Germany continues with the tradition following the very successful and productive event held in Kuala-Lumpur last year. As usual ISL 2011 brings together leading academics, researchers and practitioners to exchange ideas, views and the latest research in the field of Logistics and Supply Chain Management.

The theme of this year's 16th International Symposium in Logistics is **"Rebuilding Supply Chains for a Globalised World"**. This theme reflects the changes taking place across the world today in terms of shifting supply and demand for both goods and services, taking as a backdrop China's rapid rise, widely acknowledged now as the manufacturing hub of the world. Equally India is rapidly becoming the global services hub and other countries in the so-called 'developing world' are growing in confidence, infrastructure and capability. These changes have big implications for logistics and supply chain planning, representing a dynamic and interesting area of research and practice for both academics and practitioners alike. With this in mind the 16th ISL in Berlin aims to assemble experts from around the globe to focus on how leading firms and academics are responding to these challenges and debate what this will mean for the future of global supply chain management. Papers will represent the latest in academic thinking, as well as case examples of successful logistical implementations.

Potential authors were invited to submit an abstract to the Symposium Chairmen. All abstracts were reviewed by two experts from the International Advisory Committee and final papers were further reviewed by an International Panel of Reviewers. This book of proceedings of the accepted papers has been organised according the following categories:

- Supply Chain Management
- Supply Chain Networks, Collaboration and Culture
- Supply Chain Performance Assessment
- Risk, Uncertainty, Complexity and Visibility
- Supply Chain Dynamics and Inventory Management
- Decision Support Systems, Knowledge Management and ICT in Supply Chains
- Environmental Sustainability and Green Logistics
- Outsourcing and Customer-Supplier Relationship Management
- Design Configuration of Supply Chains
- Transport, Distribution and Third/Fourth Party Logistics
- Supply Chain Services and Emerging Markets

We would like to take this opportunity to express our sincere thanks to all the presenters, delegates, reviewers, Advisory Committee members, local organisers especially and guest speakers for their interesting and valued contributions. Finally, our very special thanks go to Alison Parrett for her wonderful all round administrative support throughout the entire organisation often under stressful, demanding and unpredictable circumstances.

Professor Kulwant S Pawar – July 2011

AUTHORS' AFFILIATION

AUSTRALIA
Monash University
RMIT University
University of New South Wales
Victoria University

BRAZIL
Federal University of Santa Catarina

CANADA
Ryerson University

DENMARK
Copenhagen Business School

EYGPT
German University in Cairo

FINLAND
Lappeenranta University of Technology
Tampere University of Technology
VTT Technical Research Centre of Finland

FRANCE
BEM Bordeaux Management School
École Supérieure de Commerce Extérieur Paris La défense
CRET-LOG, Aix-Marseille Université

GERMANY
Berlin Institute of Technology
BIBA - Bremer Institut für Produktion und Logistik GmbH
EBS Business School (EBS)
FOM Institute of Logistics and Service Management
Hamburg University of Technology
Hochschule Furtwangen University
Ilmenau University of Technology
Jacobs University Bremen GmbH
TU Dortmund University
University of Applied Sciences Wuerzburg-Schweinfurt
Universität Bremen
University of Ilmenau
University of Rostock
University of Wuerzburg

IRELAND
University of Cork

ITALY
University of Brescia
Mediterranea University of Reggio Calabria
University of Rome "La Sapienza"

JAPAN
Ryutsu Keizai University
Iwate Prefectural University
Nihon University
Nittsu Research Institute & Consulting, Inc.

KOREA
Korea Aerospace University

MALAYSIA
Universiti Teknologi MARA
University of Nottingham Business School - Malaysia Campus

PORTUGAL
ISCTE-Lisbon University Institute

SINGAPORE
National University of Singapore

SLOVENIA
University of Ljubljana

SWEDEN
Chalmers University of Technology
Stockholm University School of Business

TAIWAN
National Central University
National Taiwan Ocean University
National Kaohsiung First University of Science and Technology

THE NETHERLANDS
Tilburg School of Economics and Management
HAN University of Applied Sciences

TURKEY
Istanbul Technical University

UK
Aston University
Cardiff University
Huddersfield University
Loughborough University
Nottingham University
Sheffield Hallam University
University of Kent
University of Hull
University of Plymouth

USA
California Polytechnic State University
Tenessee State University

TABLE OF CONTENTS

SECTION 1 - Supply Chain Management **Page No.**

Being successful as a Supply Chain Manager in Fashion
H-H Glöckner, H Jordaan, R van der Veen, S Weijers 14

How do European companies judge the impact of ECFA for their business in Taiwan?
P Walker, K-m Tsai, P Bremer 21

Design and Management of International Supply Chains in a Globalised World: Changes, Challenges and Examples
J Eschenbächer, F Römer 30

Structures of Logistics and Supply Chain Research: Bibliometric Analyses of Four International Journals
C Georgi , I-L Darkow, H Kotzab 40

Towards Supply Chain Strategy Execution: An Automobile Industry Case Study with Dyads
I Sadler, D Wilden 50

The Relationship between Product Design and Supply Chain Management: A Systematic Literature Review
A Hashemi, T Butcher 57

An Exploration into the Value of Time and Cost Information in the Malaysian Food Supply Chain
L Whicker 65

Research Orientations of the Selected Supply Chain Management Periodicals: A Critical Review
S Rahman, A Abareshi, S Bakir, S Ahmad 73

Trust and the end-to-end Supply Chain Perspective
C Braziotis, N Yannopoulou, J D Tannock 81

SECTION 2 – Supply Chain Networks, Collaboration and Culture

Readiness for Supply Chain Collaboration & Supplier Integration – Findings from the Chinese Automotive Industry
J Schadel, M Lockstrom, R Moser, N Harrison 89

Co-opetitive Strategies in Supply Chains: From Information System to Social Ties
V Hiesse, H Fenneteau, G Pache 97

Lean Across Cultures: State-of-the-Art
C M Guimarães, J Crespo de Carvalho 105

Integrating the Supply Chain - The Impact of Attitudes, Patterns and Practices on Supply Chain Performance
I-L Darkow, H Wöhner, G Kaiser 116

Structural and Agentic Analysis of Supply-Chains: A Social Network Analysis Approach
A Sloane, S O'Reilly 125

Building Capacity in the Theory of Humanitarian Logistics
A Baan, E Barber 137

A Framework for Suggesting Logistics Partners for the Virtual Organization Environment
O Correia-Alves, J R Rabelo 147

SECTION 3 – Supply Chain Performance Assessment
Revisiting Importance-Performance Analysis: Factors Influencing Port Performance
M Feng, C Lalwani, J Mangan, 156

Creating A "Best Value Supply Chain"? Empirical Evidence from the Greek Food Chain
C Fotopoulos, M Bourlakis, G Maglaras 165

Linking Supply Chain Operations' Performance to the Company's Financial Strategy: A Case Study of an Egyptian Natural Bottled Water Company
S H Elgazzar, N S Tipi, N J Hubbard, D Z Leach 173

Exploring how to Sustain Business Process Improvement Gains in Complex Operations
B Evans, R Mason 182

Mobile Intelligence for Reporting of Supply Chain KPI'S
H Rogers, K S Pawar, N Tipi 190

SC Performance – A Driver of Company Performance
G Kaiser, I-L Darkow, H Wöhner 196

SECTION 4 – Risk, Uncertainty, Complexity and Visibility
Logistics Triad Collaboration as an Enabler of Uncertainty Reduction: A FMCG Longitudinal Study
V S Rodrigues, A Potter, R Mason, A de Swardt, A Robinson 201

Supply Chain Security 2030 – How Security Issues will affect Global Supply Chains
C Markmann , T Gnatzy, H A von der Gracht, I-L Darkow 209

Risk Control and Collaboration in Maritime Supply Chains
J Vilko, J Hallikas 219

Future Trends Envisaged in Supplier Relationship Management: Perspectives from Practictioners
F Olorunniwo, J Jolayemi, C Fan, X Li, 229

The Diagnosis of Complexity within a Medical Consumables Manufacturing Company
S Dhingra, A Potter, R Barton 237

Supply Chain Risk Management: An Analysis of Present and Future Scope
A Ghadge, S Dani, R Kalawsky 245

SECTION 5 – Supply Chain Dynamics and Inventory Management
Measuring the Spatial Organisation of an Auto-Parts Retail Network
P Chhetri, B Corbitt, K H Lau, F Cheong, B Kam 255

Inventory Policies of Maintenance Spare Parts: A Risk Management Model
F Constantino, M De Minicis, G Di Gravio, M Tronci 264

Collaborative Sales Plan among Farmers and Development of Arrival and Sales Planning Support System in Farmer's Store
K Shimokawara1, T Takeno, M Horikawa, M Ohba, M Sugawara 272

Sustainability Strategies in an EPQ Model with Price-and Quality-Sensitive Demand
C H Glock, C Searcy, M Y Jaber 280

Extended VMI in a Demand-Supply Network among a Sales Network, a Manufacturer and a Subcontractor Network
E Salmela, A Happonen 287

Functionalities of the Decision-Making System for Intermodal Railroad Operations
J Hemilä 296

Management of the 'Shipper - Logistics Service Provider' Relationship
J de Haan, M Overboom, F Naus 302

Exploring Out-of-Stock and Over Stock Occurences in Supermarkets – A Case Study in Singapore
E Hooi, B Kam, G Cairns 310

Spare Parts Inventory Management. A Literature Review and Directions for Future Research
F Adrodegari, A Bacchetti, N Saccani, A Syntetos 318

Analytic Hierarchy Process and its Applications in Logistics Research
S Rahman, N Subramanian, C Chan 326

SECTION 6 – Decision Support Systems, Knowledge Management and ICT in Supply Chains

Support of an Operational Supply Chain Risk Management for Sensitive Logistics Nodes
C Breuer, H-D Haasis, M Plöger, G Siestrup, H Wildebrand 335

Functional Models for Logistic Platform Based on Experimental Data
D Gattuso, G Carla Cassone, F Politi 340

Consideration of Distribution Systems that Repeatedly Re-Use Standardized Crates
E Masuda, Y Yano 349

Analysis of Directed Influences between U.S. Air Cargo Hubs from Time Series Approaches
Ch-w Shen, C-c Chou 358

Impacts of Autonomous Cooperation-Enabling Technologies on the Corporate Value of Logistics Enterprises
M Hülsmann, C Illigen, P Cordes 365

Finding a Generic Algorithm for Integrating Value-Based Objectives and Logistics Goals – Operationalization of Order Prioritizing in Production Control Based on Customer Value Management
M Hülsmann, C Illigen, K Windt, O Jeken 373

Development of a Method for Improving the Workload of Flow Lines with Non-Linear Flow of Material
A Al Khateeb 382

Stakeholder-Oriented Implementation of Sustainability into Supply Chain Management using Fuzzy Logic
N Vojdani, M Knop 387

Customer and Supplier Collaboration during Product Specification - Problems of Information Gathering and Sharing
S Wiesner, F Steinberg, M Seifert 396

Development of a Framework Supporting ICT-Based Energy Efficient Freight Transport
J B Hauge, H Westerheim, T-K Moseng 404

Potentials for Transactions in Supply Chains - Effects of Web-Based Interactions in the Media Industry
C Illigen, J Grapp, M Hülsmann 412

SECTION 7 – Environmental Sustainability and Green Logistics

Green Collaborative Practices in the Supply Chain: An Explorative Analysis in terms of Forms of Proximity
V Carbone, C Blanquart 417

The Impact of Economic Development on the Energy Efficiency and Co2 Emissions of Road Freight Transport
H Liimatainen, M Pöllänen 425

A concept to evaluate resource and energy efficiency through an utilization-based simulation for Anticipatory Change Planning of Intralogistics Systems
A Wötzel, G Bandow 433

Decarbonisation Initiatives applied within The German Logistics Sector
J Tacken, V S Rodrigues, R Mason 441

A Merger between Quality and Reverse Logistics in the Pharmaceutical Industry: A State of the Art Review
A M Santos Bravo, J Crespo de Carvalho 449

Sustainable Pharmaceutical Supply Chains: A State of the Art Review
A M Santos Bravo, J Crespo de Carvalho 458

Sustainable Supply Chains in a Globalised World
M Klumpp, W Kersten, S Brockhaus 463

Trends in the Environmental Impact of Logistics Sector Companies and an Examination of the Likely Impact of Revisions to the "Law Concerning the Rational Use of Energy"
Y Yano, E Masuda, G H Hong 474

Green Logistics Assessment: A Methodology to Measure, Evaluate and Improve the Ecological Sustainability in Logistics
F Straube, S Doch 483

eFreight Adoption for Sustainable Air Transport Supply Chain eFreight adoption for sustainable air transport supply chain
M Goh, A Tan, M Garg, H Othman, R de Souza 495

'Base' and 'Surge' Strategies for Controlling Environmental and Economic Costs in Logistic Triads.
M M Naim, A T Potter, V Sanchez Rodriguez, V L Marques 503

Green Supply Chains: An Indian Perspective
S Dani 512

SECTION 8 – Outsourcing and Customer-Supplier Relationship Management

A Mathematical Investigation of Alternative Forms of Supplier Development
C H Glock, M Y Jaber, A L Guiffrida 518

A Vendor–Buyer Supply Chain with Variable Fraction of Defectives
M Khan, M Y Jaber, C H Glock 525

The Impact of Complementary Capabilities on the Success of Logistics Outsourcing in Australia
V Lazarevic 531

Managing Supplier Relationship: Case Studies of Small and Medium Asian Grocery Retailers in Melbourne
Thi Viet Hoa Tran, Booi H Kam, C S Lalwani 539

The Development of Long Term Relationships between Consultants and Project Managers in Construction Supply Chain in Malaysia
N Faisol, H S Jaafar 547

Design and Implementation of Agile Global Supply Chains
L Purvis, M M Naim, D Towill 555

SECTION 9 – Design Configuration of Supply Chains

Closed Loop Supply Chain System with Energy, Transportation and Waste Disposal Costs
P Hasanov, M Y Jaber, S Zanoni, L Zavanella 564

Analyzing Fishery Products Shipper's Decision-Making Behaviour
T Lirn, Y C J Wu, H Chiang 571

(Re-)Positioning of Logistics Service Providers in a Globalised World – An Empirical Survey on Positioning Models and Strategic Capabilities
M Hülsmann, B Korsmeier, V Brenner, J Decker, M Krähe 586

Lead Logistics Providers for Food Chain Management – A Literature Review on Feasibility and Benefit
M Hülsmann, V Brenner 594

An Analysis on the National Logistics Efficiency with DEA
K-m Tsai, M-h Chen 602

A Reference Model for Logistics of Offshore Wind Farms - A Life-Cycle-Oriented Approach
N Vojdani, F Lootz 606

A Study of the Development and Applicability of the A|D|S 21st Century Supply Chains (SC21) Initiative
S A Morgan, P A Found 614

Process Mapping as a Tool for Improvement of Manufacturing Efficiency with Application to Pharmaceutical Industry
E A Yaseen, A A Abou Youssef 621

An Evaluation of Current European Packaging Regulations on the Core Logistics Operations of a Paper Packaging Manufacturer in Greece
E D Georgakoudis, N S Tipi, C G Bamford 629

The Impact of Contractual Safeguarding on the Effectiveness of Operational Cooperation Governance in LSP Cooperations
J S Raue, C M Wallenburg 637

Global Supply Chain and the European Textile Industry
B Moncef, M Monnet, M Benhouda 647

Redesigning the Defence Support Chain
D Notman, A Sinclair, D Clegg 657

SECTION 10– Transport, Distribution and Third/Fourth Party Logistics

Effect of Getting Backhaul Loads in Long-Distance Transportation
A Watanabe, K Sato, K Wakabayashi, Y Fujita 664

Global Supply Network Optimization by Locating Production and Distribution Facilities in the Free Trade Zone
J-D Leu, Y-T Huang, M-H Chen 672

Through Redesign of the Supply Chain Network and New Investments to More Containers - Case Study of the Port of Koper
I Trupac, E Twrdy 681

A Non-Rigid Structured Scheduling of Short-Haul Parcel Delivery Services
I S Johal, M K Lim 689

Failure and Restart of an Aisle: Solutions for a Hidden Problem with Significant Effect in High Bay Racking Systems for Warehousing
C Wildner 695

Transport of Dangerous Goods in Turkey: An Analysis in the context of EU Integration
D Çelebi, M Klumpp 703

The Future of Road Transportation – A Backcasting Study
M Zimmermann, H von der Gracht, I-L Darkow 710

Delphi Based Scenarios on the Future of Transport Infrastructure – An Industry's Long-Term Outlook until 2030
S Schuckman , T Gnatzy, H A von der Gracht, I-L Darkow 717

Cooperation between Logistic Service Providers and Shippers on Making Transportation Sustainable
R Pieters, H-H Glöckner, S W Omta, S J C M Weijers 725

Development of a Serious Game on Intelligent Cargo for Awareness Raising among Students
J B Hauge, M Seifert, J Selle, S Daniel 733

A Monitoring System for Dangerous Goods (DG) for Air Cargo Terminal
M Kim, Y S Chang 739

Value Stream Mapping in the Air Transport Industry - A Case of Air France
V Roso, K Lumsden, A Clement, M Vlody 747

Cargo Flow Demand Analysis for Major Roads in Malaysia
I R Endut, H S Jaafar, S Mohamad, M S Mat-Daud 755

Barriers to Supply Chain Integration - A Combined View of Different Partners in Port Industry
B Almotairi 761

A Study on the Improvement of Truck Transportation Efficiency for Green Logistics - Cooperative Approaches Between Transportation Companies and Shippers –
T Yoshifuji, M Saito 770

SECTION 11 - Supply Chain Services and Emerging Markets
Clashing Logics: A Teaching Case on Challenges in Industrial Service Marketing Channels
D Brozović, F Nordin, C Kowalkowski, M Viglon 778

Measuring Retail Network Efficiency through Data Envelopment Analysis
K H Lau, P Chhetri, B Kam,B Corbitt, F Cheong 783

Luxury Consumption Moves East: A UK Luxury Textile Manufacturer Prepares its Supply Chain for Chinese Demand
P Brown, O Khan 791

Operational Processes and Supply Chain Competencies of Chinese Logistics Service Providers
M J D Booi, H Kam, C S Lalwani 800

Leverage Effect of Supplier Management on Sustainable Procurement in Emerging Markets
F Straube, A Özgen, A Ouyeder 808

Product Returns Management: A Value Creation Framework
G P Dapiran, B Kam 816

Improving Coordination of Humanitarian Relief Supply Chains: The 2010 Haitian Earthquake Crisis
L Lamlenn, C Braziotis 824

The Change of the Logistics Service Provider´s Decision Making Role in Machinery Industry - from Resource Provider to Strategic Partner -
A Happonen, E Salmela 836

Innovation in Logistics Services – Halal Logistics
H S Jaafar, I R Endut, N Faisol, E N Omar 844

SECTION 1 - Supply Chain Management

BEING SUCCESSFUL AS A SUPPLY CHAIN MANAGER IN FASHION

Hans-Heinrich Glöckner, Henny Jordaan, Rita van der Veen and Stef Weijers
HAN University of Applied Sciences

ABSTRACT
This paper presents the findings of a research project on the competencies that supply chain managers in the fashion industry need, in order to perform successfully in their profession. For this research project 21 supply chain managers in the fashion industry were interviewed. The results give a clear picture of the competencies required of logistics and supply chain managers, in order to operate successfully within their companies.

INTRODUCTION
Each year over 3,200 students in the Netherlands follow a bachelor's study programme in Logistics/Supply Chain Management. As a University of Applied Sciences we set up our curriculum, based on our knowledge of and insight into the demands of the professional field. This is mainly based on lecturers' feelings and experiences which they take from their business contacts, and on formal and informal feedback from the professional field. This information is often subjective, determined by one's personal background. For a few years now, researchers of the HAN Logistics and Alliances Lectorate have done systematic research on the competencies that business people expect from graduates in the field of Logistics. The objective is to help our students reach a competency level that enables them to develop further to a management position in Logistics, or at least to perform successfully in an organization. In practice, it appears that logistics managers in many companies in the Netherlands hardly play a role in formulating the company's strategic policy. There must be a reason for this. Thinking from the perspective of the supply chain theory we can surely recognize the essential influence of logistics on the success in realizing the corporate strategy. Does it have to do with top management underestimating the logistics position? Or is the logistics manager insufficiently equipped to be of any influence to the board room? Several companies give us reason to believe that the latter is true. Why exactly is it that so few of our HBO graduates develop into positions on a strategic level?

It is interesting to ask what competencies supply chain managers have who do work for successful companies that acknowledge the value of logistics in determining strategic policy. This was the primary question in our research.
The underlying purpose of our research was to find out how we can provide our students with a better foundation, enabling them as supply chain managers to understand how they can play a relevant role in determining their company's strategic policy. We intend to reach this purpose by researching and answering three questions:

1. what competencies are required of supply chain professionals by the professional field – not only in terms of professional knowledge, but also especially in terms of skills and attitudes (leadership, communication)?

2. in what ways can such competencies be developed in higher vocational education?

3. what key factors of supply chain management are there for the success of a company?

We have chosen to carry out our research in the fashion industry, for several reasons:

Firstly, pressure on the supply chain in the fashion industry is very high. This trend can be seen in many industries, but in this particular industry pressure is extra high[1]:

- The supply chain is strongly driven by consumer demand – after all, this demand is very unpredictable;
- The products usually have a short life cycle;
- It is about global chains;
- ICT plays an important role in the supply chain.

These characteristics set high standards in terms of quickness of response, flexibility, delivery reliability and level of service. These standards can only be met if the organization has a virtually perfectly designed supply chain which closely fits their strategic (marketing) policy. The work done by the supply chain manager, therefore, is vital for the success of the organization.

Our consideration was to choose an industry where pressure on Supply Chain Management (SCM) is extremely high, in order to distinguish very clearly what factors can make SCM successful.
Secondly, we chose to focus on the fashion industry because there are several successful company strategies. Zara's strategy, for example, is to keep things under their own control and to keep all processes under control as much as possible. This strategy is successful, but so is Zeeman's or Benetton's, even though they work with very different supply chain concepts. The fashion industry is truly complex. Some companies are only retailers, others combine retail with production, or with wholesale. Some focus on the trendsetters' market, others on fashion, Basics and/or Never out of Stock (see figure 1). By comparing the supply chain characteristics of fashion companies with different strategies, interesting conclusions can be drawn regarding their chances for success.

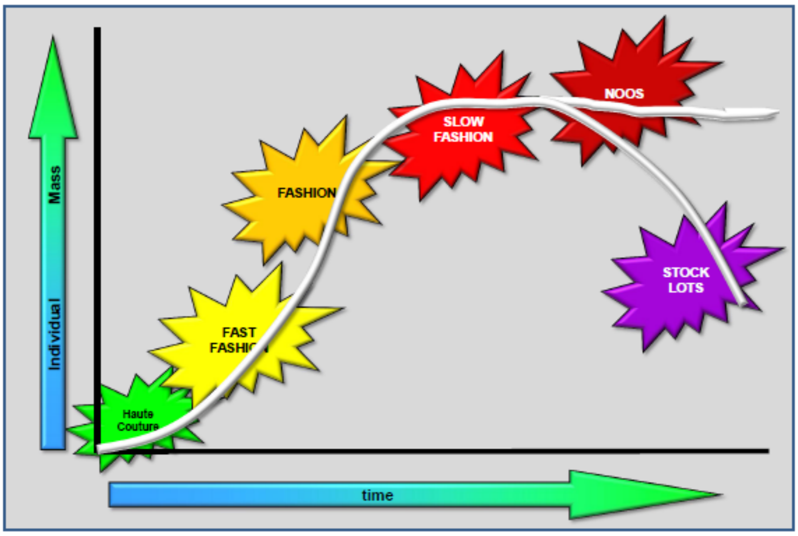


Figure 1: Market Positioning
Please note: Time in this graph stands for how long a products remains fashionable

Our research is in its first stage. In this paper we present the first results.

RESEARCH METHOD

[1] Aquino, D. and L. Draper (2008)

For the first phase of our research we interviewed 21 supply chain professionals working for fashion companies. For these interviews a questionnaire was drawn up, containing the following aspects:

1. general information about the company
2. general information about the supply chain professional
3. questions about competencies and the development of competencies
    a. What knowledge does the SC manager need in order to carry his/her job?
    b. What behavioural competencies does the SC manager need in order to carry out his/her job?
    c. How has the SC manager developed his/her competencies?
    d. What events occur which lead to important learning experiences?
    e. What learning activities has the SC manager gone through?

The questions asked in the interviews were open questions. The reason why we chose for open questions was that we wanted the interviewees to answer spontaneously and that we did not want to put words in their mouths. After all, we did not intend to test our ideas, but to gain knowledge about this. In other words, it was exploratory research. In our selection of the companies to be interviewed we tried to include a diverse selection of companies, in terms of strategy, market sector, size, geographic reach (national, international) and how fast their collections are taken through the supply chain. In figure 1 this is indicated with the terms "fast-fashion, fashion, slow-fashion and never-out-of-stock (noos)".
The SC managers interviewed were very willing to participate in our research. The interviews about the professionals' personal development and the role and method of logistics in their companies yielded a wealth of information which yet has to be processed further. This paper covers the part of our research that could be processed statistically.

RESULTS

A few years ago Veereecke et al (2008) carried out similar research among supply chain managers, although their research was extended to other aspects as well; they conducted their research among 743 respondents from various branches of industry. Results that are comparable to ours are indicated between brackets, added by a "V".

Level of education and study programme of the SC managers
Of the 21 interviewees, 7 respondents (=33%; V: 62%) have a university degree and 11 (=52%, V: 32%) graduated from higher professional education (HBO). Two interviewees obtained their diplomas at secondary school and one interviewee finished senior secondary vocational education (MBO). This shows that it is very well possible to graduate with a bacherlor's diploma and develop further to a position at strategic level, or a position close to this.

14 out of the 18 SC managers with an HBO or university education (= 78%, V: 49%) followed a study programme in economics. Three finished a technical study programme and one graduated from a computer technology study programme. 5 of the managers studied in a logistics programme.

Level, working field and process responsibility in an SC managing position
In order to gauge the SC manager's influence on a company's policy it is helpful to indicate the level of the SC manager's position in the organization. We distinguish four different levels:

Job level	Number of interviewees
1 Managing director / Owner	3
2 Member of the management board	8
3 Department manager	9
4 Other	1

Table 1: Interviewees' job levels

Most supply chain managers we interviewed hold a position at level 2 or 3. Additionally, we asked if their field of work was national, European, or worldwide. The conclusion was that for the most part, the SC managers deal with international chains. 6 out of 21 SC managers work at a national level, while 7 are responsible for the supply chain at a European level and another 8 operate worldwide.

An SC position is also characterized by the level of responsibilities for management processes. For this we based our research on the SCOR model. The results show the division below:

Plan	Source	Make	Deliver	Return
14	4	5	20	18

Table 2: Responsibilities of the SC manager for management processes according to SCOR

The core tasks of the SC manager are to provide guidance of the chain through planning, the execution of the delivery and dealing with returns. Purchase and production are part of the SC manager's responsibilities if the fashion company has its own production. If the company is a retailer only, purchase and production are rarely the responsibility of the SC manager.

Experience in SC positions

As researchers we were also interested in hearing how long the interviewees have worked in a certain SC position and in their company in general, and if this was an important aspect.

Years	Holding an SC position	Working for the company
0 - 5	5	7
5 - 10	4	6
More than 10	12	8

Table 3: The number of years in which the interviewee has worked in a supply chain position and for their current company in general

These results show that the majority of the SC managers interviewed have much experience in supply chain management. Also, the SC managers have quite a lot of experience gained in their current company.

Knowledge and behavioural competencies needed

The respondents were asked open questions about the fields of knowledge they deemed necessary. In doing our research, it is not easy to draw up a ranking based on the respondents' answers. On the other hand, this method of using open questions does show which fields of knowledge the interviewees see as most important. In table 4 we have clustered the answers that were given. For example, all answers mentioning costs were combined under knowledge about business economics. Performance indicators, on the other hand, remained a separate topic. We realize that other combinations are also possible; our combination suffices as a preliminary classification.

Field of knowledge	Number of interviewees who mentioned this field of knowledge
Business economics	17
Information and communication technology (ICT)	16
Warehouse Management	13
International trade/customs procedures	11
Commercial knowledge	9
Knowledge of processes and process control	8
Transport	5
Purchase	5
Performance indicators	4
Recent technological developments	4
Overview of the chain	4

Table 4: Fields of knowledge that the SC managers interviewed regard as important for performing well in their position

Notable, but not surprising, is the fact that knowledge of business economics and ICT scored highest. An important task of an SC manager is, after all, to make sure the chain works at low costs. To guide this process, insight into cost structures are essential, and so is knowledge of a well-structured, cogent ICT system.
Besides this, the answers given showed a trend that had been noticed earlier (Veereeke, A. et al., 2008): knowledge of the business context, e.g. knowledge of laws and regulations and international business practices are becoming increasingly important.

When it comes to behavioural competencies, the personal characteristics that are particularly expected of the SC manager include flexibility, a high level of intrinsic motivation, curiosity and immunity to stress. On top of this, an SC manager must have outstanding communicative skills and leadership qualities: dealing with people, communicating at different levels, being able to motivate others. Lastly, an SC manager's way of thinking and the actions they take are important for success: using a problem solving, action oriented approach, being pro-active, thinking strategically, being customer-oriented, thinking and working in a multidisciplinary way, and supporting cooperation.

Behavioural competency	Number
Dealing with people/socially capable	15
Flexibility	13
Using a problem solving, action oriented approach	13
Showing a high level of intrinsic motivation	9
Anticipating, being pro-active	8
communicating at different levels	8
Curiosity	8
Being able to motivate others	8
Being able to think strategically, having vision	8
Immunity to stress	7
Customer oriented	6
Being able to think and work in a multidisciplinary way	6
Willingness/ability to cooperate	6
Serving as an example	5
Having a sense of responsibility	5
Empathy	5

Patience	4
Being able to listen	4
Tenacity	4
Eye for detail	3
Analytical skills	3
Language skills	3
Being able to translate strategy to a tactical and operational level	3
Being able to delegate	3
Self-knowledge	3
Willingness to change	2
Being passionate about one job	2

CONCLUSIONS:
In this paper we present the first conclusions of our research. Shortly, we will also publish the rest of our findings, especially about SC managers' learning experiences. For now, we have drawn the conclusions below:

1. The supply chain managers we interviewed are professionals with a high level of intrinsic motivation and curiosity. After finishing each interview, this was the impression that interviewees consistently left with us. This is also the image that the supply chain managers have of themselves.

2. A successful SC manager must have knowledge of logistics; classical logistics knowledge, with a substantial amount of knowledge about costs and ICT. In addition, knowledge of the business context – international trade, customs procedures – is becoming increasingly important.

3. However, having knowledge of logistics in itself is not enough. To be successful the SC manager is expected to possess
    a. well-developed personal attitudes
    b. good communication skills
    c. the ability to keep thinking and actions in good harmony.

4. Especially personal attitudes stand out, but also communication and thinking and actions are important.

5. The things mentioned above show that there are high expectations of supply chain managers. Facing these expectations, it helps if an SC manager has a fair share of experience in both the supply chain and the company. Many managers we spoke had already been active in the supply chain for a long time, and quite long in their company as well. Knowledge of the business context is greatly important.

6. These requirements also ask a lot of universities. How should students be trained to develop their personal attitudes in order to become successful SC managers? In fact, we do not know very much about the question how we, as a University for Applied Sciences, can help students to develop their attitudes in a SCM business context. Is it only possible to improve one's attitude in business practice? How can these processes best be guided or managed? What elements can be incorporated in current curriculae of universities?

7. These kinds of questions have to be addressed in the next phase of our research.

REFERENCES

Veereeke, A., Dierdonck. R. van, Boute, R. (2008), Supply Chain Managers – who needs them? Insights from a European survey on the Supply Chain Manager, Conference presentation, http://www.vlerick.be/go/goodmanchair

Weijers, S., Glöckner, H.-H., Pieters, R. (2007), A Different Logistics Manager? – Differentiation in Logistics Business Practice, in: Developing Sustainable Collaborative Supply Chains, Proceedings of the 12th International Symposium on Logistics, Nottingham

Aquino, D. and L. Draper "Supply Chain Talent: State of the Discipline" AMR research, April 2008.

HOW DO EUROPEAN COMPANIES JUDGE THE IMPACT OF ECFA FOR THEIR BUSINESS IN TAIWAN?

Peter Walker[1], Kune-muh Tsai[2], Peik Bremer[3]

[1] Department of Logistics Engineering, University of Applied Sciences Wuerzburg-Schweinfurt, Germany
Peterw153@gmx.de

[2] Department of Logistics Management, National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan
kmtsai@ccms.nkfust.edu.tw

[3] Department of Logistics Engineering, Faculty of Business Engineering, University of Applied Sciences Wuerzburg-Schweinfurt, Germany

ABSTRACT

Taiwan has developed over the last two decades from a low-wages mass producer to a high-tech service economy. It has shown a sustainable economic growth during the last 8 years (excluding the crisis year of 2009) Due to its advanced health and education system and other factors it seems to be well prepared for the future. This is also shown in the current World Economic Forum Global Competiveness Report that calculates a Global Competitiveness Index by considering 12 different factors, such as Infrastructure, Higher Education and Innovation. Taiwan is listed in 13th place out of a total of 139 global economies. This equates to rank 3 among Asian countries (only Singapore and Hong Kong are ranked better)[1]. After having signed the Economic Cooperation Framework Agreement (ECFA) between Taiwan (**R**epublic **o**f **C**hina, ROC) and China (**P**eople's **R**epublic of **C**hina, PRC) on 29th June 2010, R.O.C.'s economic and its political future is being currently reassessed by many foreign observers. The agreement, which has been in force since the first of January, 2011, opens new prospects for Taiwan to develop further Free Trade Agreements. China will definitely be one of the three biggest growth markets of the world's economic future in the upcoming decade. Therefore, a possible future status of Taiwan is to take the role as an "Asian Economic and Cultural Hub" for companies to gain a foothold into the Chinese or the entire Asian market. Taiwan already provides competitive attributes such as infrastructure, political and social stability as well as sophisticated business networks and cultural tolerance among other strengths, which characterizes it as an expanding potential partner and a possible link to Chinese Market.

KEYWORDS
FTA, ECFA, China, Taiwan

I. ECFA AND ITS DEVELOPMENT

The economic liberalization between Taiwan and China has come from a long history. Since the late 1990s, Taiwan made several concessions to China. The existing trade ban with China has begun to be loosened step-by-step since 1997. In 2001, the port of Kaohsiung was opened for Chinese imports to the "Special Processing Zones" beyond Kaohsiung. After the accession of both countries into the World Trade Organization (WTO) around 2002 (PRC, Dec., 2001, ROC, Jan., 2002) China in particular relaxed its commercial restrictions, while Taiwan still maintained among other things its negative list but has continued to gradually relax existing restrictions (Figure 1).

In May 2004 a total of 3 Taiwanese ports and all the Chinese harbors were opened for waterway trading. In 2008 both eased their flight restrictions between the states. Since then daily direct flights have been allowed and offered. The summit of the preliminary conclusions in rapprochement was followed by the entry into force of the Preferential Trade Agreement (PTA) named ECFA. The effect of this liberalization has been an increase of imports and exports (Figure 2 & Figure 3) between Taiwan and China. Actually, in 2009, Taiwan's export to China reached US$85.7 billion, or 42% of Taiwan's total export.

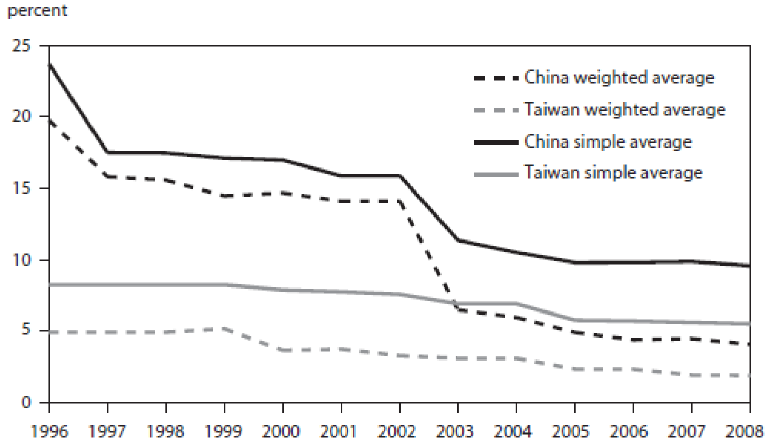
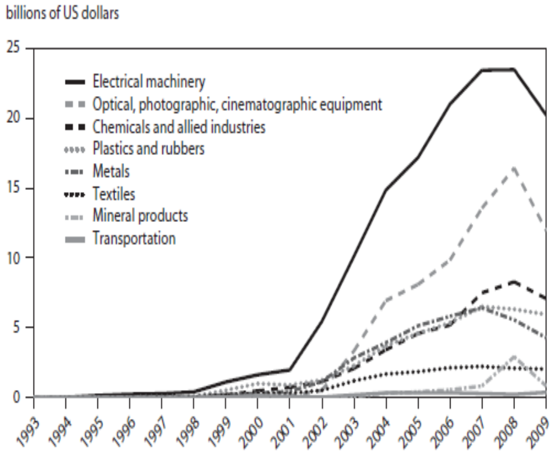


Figure 1: China's and Taiwan's most favored nation tariff levels, 1996-2008[2]



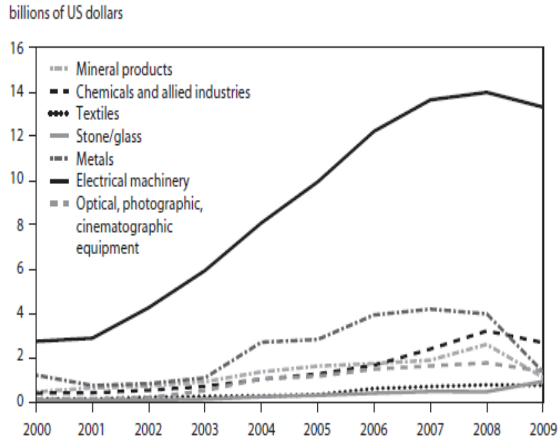


Figure 2 & 3: ROC exports to PRC (1993-2009)[2]; ROC Imports from PRC (2000-2009)[2]

The former and current restriction policy of ROC and the relative liberal behaviour of PRC in relation to Foreign Direct Investments (FDI) and settlements led to unilateral dependence. Also the possibility of utilising the Hong Kong link for FDI and other economic links into Mainland China motivated Taiwanese entrepreneurs to share Chinese growth opportunities. On the other hand China was prevented from gaining influence inside of the Taiwanese market by complying with FDI or participating in Taiwanese Companies. This astonishing dependence shows that many Taiwanese businesses are involved inside the Chinese market but not vice versa. Actually, a Chinese FDI into Taiwan was virtually non existent prior to 2009.

a. Necessity of ECFA

The ECFA should be the basis for the building of a competitive market environment inside Asia, which is absolutely necessary in view of the many existing FTAs in this sector (e.g. ASEAN). ECFA is an organic contract, which has been conceived to grow and to be negotiated constantly. Therefore institutions and administrative offices have been formed to support the Agreement and bring it forward and thus improve the economic relationship between the cross-strait nations. Not only a list with goods for the reduction of tariffs is included within this agreement, but also the liberalization of financial services and other service sectors have been negotiated. Comparing the development of Hong Kong in comparison to ROC after the two incisive developments in 1997 (reintegration to PRC) and 2003 (signing CEPA with PRC), one can easily forecast the speed of potential development in Taiwan during the current decade. However it should be noted that the two agreements were made under different circumstances. Hong Kong grew simultaneously with China during the last 15 years, albeit from a much higher economic level. Hong Kong's annual increase in its merchant fleet has risen continuously after the year of recession in 1998. After Closer Economic Partnership Arrangement's (CEPA) coming into in force (2003) the increase has accelerated (Figure 4).

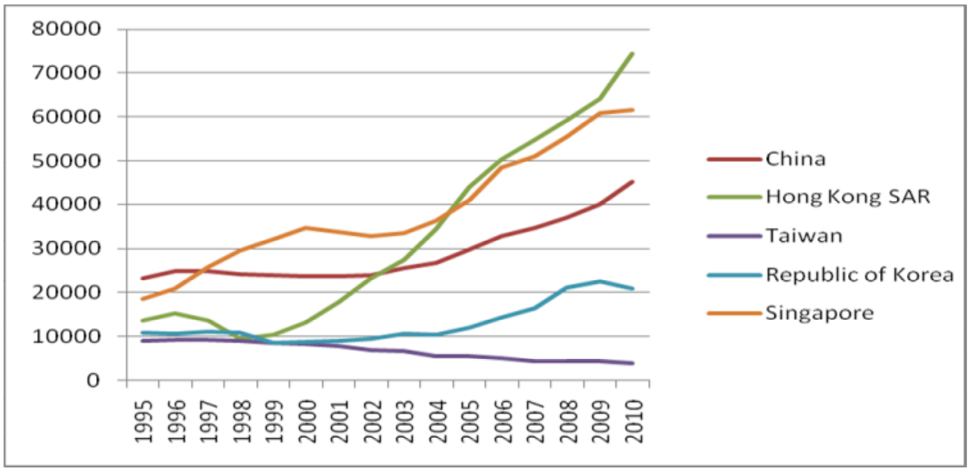


Figure 4: Annual merchant fleet (1995 – 2010), tons in thousand [5]

b. The Prospect of ECFA

After several other Asian harbours rose in ranking and Taiwan's Status fell steadily. many experts are of the opinion that the future economic outlook for Taiwan should be viewed optimistically. Estimates range from 1.7 % surplus of Gross Domestic Product (GDP) [6] after ECFA has come into force to more than 4.4 % over normal level of GDP in the year 2020 [2]. The ECFA also makes Taiwan appealing to foreign Investors and Entrepreneurs. An increasing number of sales of Taiwan Depositary Receipts after the speculation due to the signing of a cross-strait agreement was observed by the Li & Fung research centre, which states: 'The ECFA, coupled with the progress in Three Linkages and government policies' to lure foreign investment, will enhance the incentive for multinationals to invest in Taiwan.' They also forecast Taiwan as the new gateway into the Chinese market (former Hong Kong) [6]. Catherine Ashton, the High Representative of the European Union for Foreign Affairs and Security Policy, also stated that the "European Union believes that the expansion of cross-strait economic relations has a potential to benefit the development of its already significant trade and investment links in East Asia." The European Chamber of Commerce Taipai in a Position Paper (October 2009) stated the absolute necessity of a PTA between ROC and PRC. In the first half year of 2010 the FDI increased by 22.5 % from the same period a year before. [6]

II. SURVEY AND RESULTS

For European companies, it is thus interesting to conduct research into Taiwan-based European Companies to judge the effect of the ECFA and the outcome for those companies and their branches. Besides, how these companies will handle investments in the upcoming years and how the ECFA influence their actions and their strategic thinking affect their future strategy in Taiwan and Chian. Taking into account all the facts and forecasts about the ECFA by many institutions, it is expected that they will have obtained optimistic answers and forecasts. Especially in the industry branches which are most benefited by the Early Harvest List of goods and services. We designed a questionnaire having three main parts (common questions, import, export) to be sent out to over 350 European companies, which are all currently represented in Taiwan. After two months and three times of reminder via e-mail, 26 valid answers were received. Auxiliary to the questionnaire for the European companies in Taiwan, we also conducted several interviews with those who are responsible representatives of several European Trade and Investment Chambers. Based on the size of annual sale, the returned samples can be divided into 3 categories - less than 6.5 million NT$ per year (**S**mall **E**nterprises, accounts for 19%), between 6.5 million and 285 million NT $ (**M**idsize **E**nterprises, account for 39%) and more than 285 million NT$ (**L**arge **E**nterprises, account for 42%). The sample companies can also be categorized, in relation to the opinions toward the effect of the EFCA, into: ECFA-benefited and ECFA-disadvantaged or neutral affected. By performing the cross-tabulation analysis of the annual sale and the opinions toward the effect of the EFCA, we found that middle and large size of companies evaluate the ECFA on average as an advantage, because many FTAs created a positive effect after coming into force and bigger economies have the funds and knowledge to profit more from such an improvement than is normally the case with smaller companies. Surprisingly nearby a third of the SE consider ECFA to be an advantage on average while only 12.5% of the ME consider ECFA as more advantageous for them than for their competitors.

No	***Keywords***	***Question***
1.2.	Sales Volume	What was your sales volume in Taiwan in 2009? (Classification German Tax law 01.01.2010)
1.3.	Two-Year-Development Taiwan	What do you expect about the development of your branch in Taiwan during the next two years? [strongly declining (1) - strongly increasing (5)]
1.4.	Number of Competitive Chinese Products	What do you expect about the number of competitive products from Mainland China (MC) in Taiwanese market during the next two years? [strongly declining (1) - strongly increasing (5)]
1.5.	Future Investment Behaviour Taiwan	How do you estimate your business investment behaviour in Taiwan in the next 5 years? [strongly declining (1) - strongly increasing (5)]
1.6.	ECFA Influence	How does the ECFA influence this decision? [not at all (1) - exclusively (5)]
1.7.	Future Investment Behaviour China	How do you estimate your business investment behaviour in MC in the next 5 years? [strongly declining (1) - strongly increasing (5)]
1.8.	ECFA Influence	How does the ECFA influence this decision? [not at all (1) - exclusively (5)]
1.9.	ECFA Advantage Estimation	All in all: Do you estimate the ECFA contract as an advantage for your company? [almost not (1) - in an outstanding form (5)]
2.1.	Import Behaviour Chinese Products	Do you actually import goods from MC or have you planned to import goods from MC during the next two years?
2.2.	Assortment Exchange Chinese Products	Have you planned to exchange your assortment of purchased parts with goods from MC during the next two years?
2.3.	Price Development (Early Harvest Products)	What development do you expect for the average price level of ECFA-listed goods during the next two years? [strongly declining (1) - strongly increasing (5)]
2.4.	ECFA Influence	How does the ECFA influence this development? [not at all (1) - exclusively (5)]
2.5.	Estimation Tariff Development	How do you estimate the decrease of import tariffs for your business? [very negative (1) - very positive (5)]
3.1.	Export Behaviour MC	Do you actually export goods to MC or have you planned to export goods to MC during the next two years?
No	***Keywords***	***Question***

3.2.	Taiwan as a Gateway?	Please estimate following conclusion referring to your branch: "Some multinationals may see Taiwan as a priority cooperation partner and gateway to enter the Chinese Mainland market."[1] We agree [not at all (1) - exclusively (5)]
3.3.	Export Forecast Comparison	How does your company forecast the Quantity of Export to MC for the coming years in relation to 2009?
3.3.1.	Forecast 2010	2010 [decrease - > 50%]
3.3.2.	Forecast 2011/12	2011 / 2012 [decrease - > 50%]
3.3.3.	Forecast 2013/14	2013 / 2014 [decrease - > 50%]
3.4.	Future Chinese Price Development (Branch Interior)	What development do you expect inside your branch for the average price level of goods sending to MC ? [strongly declining (1) - strongly increasing (5)]
3.5.	ECFA Influence	How does the ECFA influence this development? [not at all (1) - exclusively (5)]
3.6.	Freight Split Export	How was your average split of export freight in 2009?
3.7.	Forecast Freight Split	How do you estimate the future development (2011/2012) of seafreight for your business? [strongly declining (1) - strongly increasing (5)]

Table 1: Questions

		SE □ (n)	n	**ME** □ (n)	n	**BE** □ (n)	n
1.2. Sales Volume		27%	26	31%	26	42%	26
1.3. Two-Year-Development Taiwan	1 2 3 4 5	3,9	7	3,6	8	3,6	11
1.4. Number of Competitive Chinese Products	1 2 3 4 5	2,6	7	3,1	8	3,5	11
1.5. Future Investment Behaviour Taiwan	1 2 3 4 5	3,6	7	3,5	8	3,6	11
1.6. ECFA Influence	1 2 3 4 5	1,9	7	2,0	8	2,3	11
1.7. Future Investment Behaviour China	1 2 3 4 5	3,3	7	4,0	8	3,2	11
1.8. ECFA Influence	1 2 3 4 5	2,3	7	2,3	8	2,0	11
		SE □ (n)	n	**ME** □ (n)	n	**BE** □ (n)	n
1.9. ECFA	1	2,4	7	2,0	8	2,3	11

		SE □ (n)	n	**ME** □ (n)	n	**BE** □ (n)	n
3.1. Export Behaviour MC	Yes	71%	7	38%	8	45%	11
	No	29%		63%		55%	
3.2. Taiwan as a Gateway?	1 2 3 4 5	2,6	5	2,7	3	3,2	5
3.3. Export Forecast Comparison *3.3.1. Forecast 2010*	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	7,5%	5	2,5%	3	6,0%	5
3.3.2. Forecast 2011/12	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	11,0%	5	5,0%	3	9,0%	5
3.3.3. Forecast 2013/14	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	19,0%	5	5,0%	3	11,5%	5
		SE □ (n)	n	**ME** □ (n)	n	**BE** □ (n)	n
3.4. Future	1	3,0	5	3,0	3	3,2	5

Advantage Estimation	2 3 4 5						
2.1. Import Behaviour	Yes No	57% 43%	7	25% 75%	8	55% 45%	11
2.2. Assortment Exchange Chinese Products	Yes No Contrary	25% 75% 0%	4	100% 0% 0%	2	17% 83% 0%	6
2.3. Price Deve-lopment (Early Harvest Products)	1 2 3 4 5	3,0	4	2,5	2	2,8	6
2.4. ECFA Influence	1 2 3 4 5	2,3	4	2,0	2	2,8	6
2.5. Estimation Tariff Deve-lopment	1 2 3 4 5	3,0	4	3,0	2	3,2	6

Chinese Price Deve-lopment (Branch Interior)	2 3 4 5						
3.5. ECFA Influence	1 2 3 4 5	2,6	5	2,0	3	2,2	5
3.6. Freight Split Export	Sea Air	41% 59%	6	66% 34%	7	65% 35%	9
3.7. Forecast Freight Split	1 2 3 4 5	2,7	7	3,5	8	3,4	10

Table 2: Answers structured by size of enterprise

However their actual answers are slightly surprising: More than 71 % from the SE answer the question as to their expectations of developments in their branches based in Taiwan during the next two years with the expectancy of an increase in turnover. Currently more than 60% of the ME and BE share this optimistic view. In no category did anyone estimate shrinkage in their branch. The following question about their scheduled investment inside of Taiwan during the next 5 years affirms the presumption: 42.86% of the SE, 50% of the ME and 54.55% of the BE are planning to increase their investment. When asked whether the ECFA had influenced their investment decisions, 57.14% of the SE declared that the ECFA had not affected their decision. By comparing the results from ME (50%) and BE (36.36%) that claim a high or an exclusive influence (12.5% ME and 18.18% BE) we can conclude, that they have more confidence in a generally stable growth than in huge effects from ECFA. Considering the internal investment plans of the PRC 75 % of the ME have the intention of spending more money to expand their business. Slightly more than 16% of them estimate the influence of ECFA as highly or exclusively responsible for this decision. As expected the SE are very cautious (28.57%) about increasing investments in Mainland China (MC) and only less than 10% of the BE intend to decrease their investments in MC. For the second round of questions (import) the companies were separated into those who currently import goods from MC and those who do not. Only the 12 importers were asked to answer the questions in this sector. Asked for their expectation about price level changes of ECFA listed goods during the next 2 years a majority of 66.67% believes in stability. But more than 80% think that the ECFA has some impact on price formation. The last set of questions was put to the 13 companies which have already exported goods to MC. They first had to answer the following question: Please comment on the following conclusion referring to your branch: 'Some multinationals may see Taiwan as a priority cooperation partner and gateway to enter the Chinese Mainland market. [6] It was interesting to observe, that all companies agreed at least partly with this conclusion. The BE more than the ME and the ME more than the SE (3.2.). The longer the term the better the outlook! This could be concluded by interpreting the forecast of the companies for the upcoming years.

		E0 □(n)	n	**E+** □(n)	n
1.2. Sales Volume	[redacted]	19%	26	81%	26
1.3. Two-Year-	1	3,8	5	3,7	21

		E0 □(n)	n	**E+** □(n)	n
3.1. Export Behaviour MC	Yes No	40% 60%	5	57% 43%	21

Development Taiwan	2 3 4 5				
1.4. Number of Competitive Chinese Products	1 2 3 4 5	3,6	5	3,0	21
1.5. Future Investment Behaviour Taiwan	1 2 3 4 5	3,2	5	3,6	21
1.6. ECFA Influence	1 2 3 4 5	2,8	5	1,8	21
1.7. Future Investment Behaviour China	1 2 3 4 5	3,6	5	3,5	21
1.8. ECFA Influence	1 2 3 4 5	2,4	5	2,0	21
1.9. ECFA Advantage Estimation	1 2 3 4 5	2,8	5	2,0	21
2.1. Import Behaviour	Yes No	0% 100%	5	52% 48%	21
2.2. Assortment Exchange Chinese Products	Yes No Contrary	-	-	27% 73% 0%	11
2.3. Price Development (Early Harvest Products)	1 2 3 4 5	-	-	2,7	11
2.4. ECFA Influence	1 2 3 4 5	-	-	2,4	11
2.5. Estimation Tariff Development	1 2 3 4 5	-	-	3,0	11

3.2. Taiwan as a Gateway?	1 2 3 4 5	2,5	2	2,9	12
3.3. Export Forecast Comparison *3.3.1. Forecast 2010*	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	7,5%	2	5,6%	12
3.3.2. Forecast 2011/12	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	11,3%	2	9,0%	12
3.3.3. Forecast 2013/14	-2,5% 0% 2,5% 7,5% 15% 25% 40% 50%	11,3%	2	13,3%	12
3.4. Future Chinese Price Development (Branch Interior)	1 2 3 4 5	3,0	2	3,1	12
3.5. ECFA Influence	1 2 3 4 5	2,0	2	2,4	12
3.6. Freight Split Export	Sea Air	65% 35%	5	61% 39%	21
3.7. Forecast Freight Split	1 2 3 4 5	3,8	5	3,2	20

Table 3: Answers structured by benefit of ECFA

It gets very interesting when the groups are separated into ECFA-benefited (E+) and ECFA-disadvantaged or neutral effected (E0) companies. The supposed better situated companies don't evaluate themselves in a benefit position. Approximately 50% of the E+ does not estimate ECFA as an advantage for their company. No one of the E0 group expects to import goods from MC during the next two years, while over 50 % of the E+ companies have planned to import goods from MC during the next 2 years or have already imported goods from MC. 63.64% of the E+ companies estimate the tariff reduction as disadvantage or effect less for their business!

Roughly 50% of the E+ companies estimate the development in amount of export goods to MC in the next 4 years in an equal or decreasing way.

III. Interview Results

In addition to the results of the questionnaire, we made an interview with several European Trade Representatives from different countries, including Austria, Belgium, Denmark, Germany, Italy, Switzerland, in Dec. 2010. Here some extracts of the widespread answers.

Q1: How, in your opinion, are the development prospects for European companies in Taiwan affected by the ECFA-Signing in June 2010 by Mainland China and Taiwan – more advantageous or disadvantageous?

A1: 'The signing of ECFA is advantageous for European firms in Taiwan. Those who do business in Taiwan focus on Taiwan and surrounding markets, of which China the biggest. The amiable and further economic tie by the signing of ECFA certainly help European firms market expansion in this region.'

Q2: Do you assess Taiwan as a Chinese gateway for foreign companies?

A1: 'Taiwan has always been seen as a hub to develop the access to Mainland China. Compared with Mainland China, Taiwan has a more business-friendly environment, better infrastructure, open society and politic atmosphere. Thus, if the ECFA works well, it can be a real asset for Taiwan, and besides, Taiwan can play a good role in the ASEAN area as well.'

Q3: Do you judge the signing of ECFA as the beginning of further Taiwanese Free-Trade-Contracts (e.g. with ASEAN-members) within the next five years and how would such a development impact the decision of European Companies to conduct business inside of Taiwan?

A1: 'ASEAN is not a major trading partner for both, Taiwan and for Europe. It would help to enhance trade exchanges and investment activities that would also be beneficial for European companies.'

IV. CONCLUSION

The European Companies and the European Representatives of several European Economic Interest Groups in Taiwan assess the ECFA not as optimistic as it could be assumed. This could be caused by the cautious attitude European entrepreneurs hold, especially after the recently conquered world economic crisis. However, if you look at the results in detail, it can definitely be said that the economic future of Taiwan appears in a bright light. According to the respondents, Taiwan had made a step toward the right and opening direction. This step was necessary and probably overdue. Nonetheless, Taiwan has to be careful not losing its political independence through economic dependence.

REFERENCES

[1] The Global Competitiveness Report 2010-2011 (2010), World Economic Forum

[2] Rosen & Wang (2011), The Implications of China-Taiwan Economic Liberalization, Peterson Institute for International Economics

[3] Asia Regional Integration Center (2011), www.aric.adb.org/FTAbyCountryAll.php, <Retrieved April 20, 2011)

[4] Bureau of Foreign Trade (2011), www.eweb.trade.gov.tw, <Retrieved April 20, 2011>

[5] United Nations UNCTAD (2011), www.unctadstat.unctad.org, <Retrieved April 24, 2011>

[6] Li & Fung Research Centre, China Distribution & Trading Issue 67 (2010), www.idsgroup.com, <Retrieved March 10, 2011>

DESIGN AND MANAGEMENT OF INTERNATIONAL SUPPLY CHAINS IN A GLOBALISED WORLD: CHANGES, CHALLENGES AND EXAMPLES

J. Eschenbächer, F. Römer
BIBA - Bremer Institut für Produktion und Logistik GmbH (BIBA)
Hochschulring 20, 28359 Bremen, Germany
Email: esc@biba.uni-bremen.de

Keywords:
International supply chains, supplier networks, ICT technologies, cross-cultural issue

ABSTRACT
The management of international supply chains is a fairly new academic discipline among logistics. After a boom in the nineties, basic principles, definitions and processes have quickly been agreed on and management tools are available today. Nevertheless, disruptive changes like the financial crises and the continuing globalisation recently prove the current international supply chain management (ISCM) understanding to be too inflexible and ignorant of intensifying global SCs. This paper explains the most important threats of future SCs with representative examples, synthesises key requirements and challenges and presents new approaches to face future developments in international and inter-corporation production and supply planning. A few promising approaches and concepts are listed in conclusion.

1. Introduction

The complexity and fragility of ISCs hasn't been demonstrated adequately, let alone, answered with sound concepts (Harmut 2008, Chopra and Meindl, 2010). The main reason is the unawareness of newly arising threats and a lack of real case studies. Consequently, this paper will roughly explain the importance and structure of global SCs in the beginning and thereafter intend an assembly of new tendencies, requirements and challenges that will most likely cause major problems. The overview over recently emerged threads will be completed by a series of conclusions drawn from the experience and best-practices of various companies and market actors. Inherent but already well studied problems like cultural differences are let out in this context.

2. International supply chains

Whereas production in earlier times and even up to the 70ies could be characterised by linear flows from the raw material supplier to manufacturers and to the respective markets, today, highly specialised international production networks of countless (sub-) contractors, suppliers, externalised business partners, research facilities, manufacturing sites, consultants, etc., have been created to optimise business operations. These SC networks leverage local advantages, such as resources, cheap labour or expertise, to produce almost any modern product and pre-product at large quantities and low prices (Holger 2004). ISCs are, if implemented correctly an in the right context, presently the most powerful tool to organise business, generate value and answer requirements and chances of a rapidly growing global economy (Schieck 2008, Pfohl 2004, Branch 2009; Chopra and Meindl 2010). It might even be argued that modern SCs are currently the most sophisticated and efficient form of international division of labour in the sense of David Ricardo and constitute a highly important if not crucial part of modern economy. Moreover, there is a consensus in science and practice that SCs will continue to grow in importance over the next decades. **Error! Reference source not found.**Figure 1 illustrates the development from classical logistics to modern SC Networks as perceived by science today.

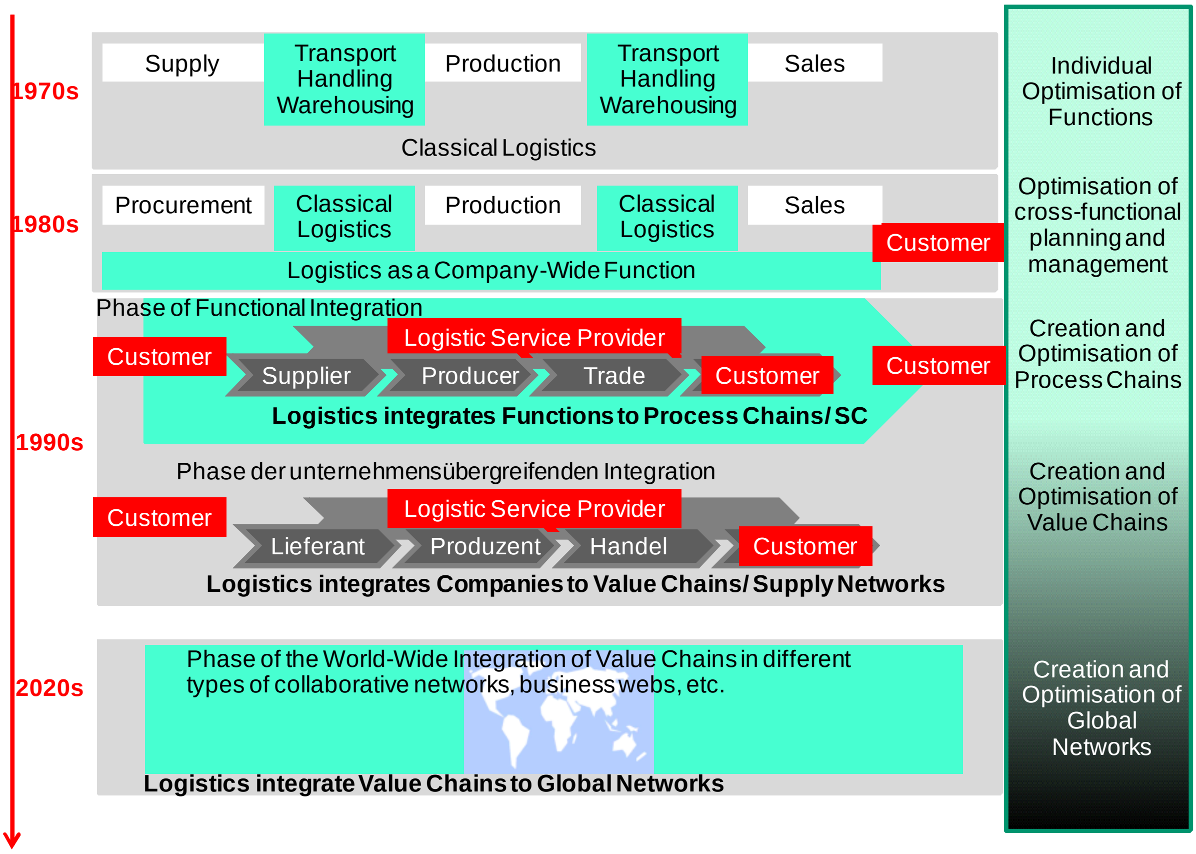


Figure 1: Development of Logistics (compare to Baumgarten 2008)

2.1. Globalisation: towards global, multi enterprise orchestration

In essence, the extreme cost pressure imposed by global competition and the increasing complexity of products might be considered as the main push-factors of globalisation and the implementation of ISC networks. On the other hand, also ICT-based communication and management tools (enabler), emerging markets as well as decreasing transportation times and costs have to be highlighted as crucial pull factors (SCC 2010; Tang and Nurmanya Musa 2011, Chopra and Meindl 2010, Günther et al, 2007). As a result, the majority of competitive companies are today embedded in global networks of one or another kind. Indeed, only 6% of the US-American companies receive all pre-products from national suppliers and production at the moment. Considering that this number used to be around 18% just two years ago, one can imagine the high velocity of this process (IDC 2010). **Error! Reference source not found.**Figure 2 synthesises the increasing internationalisation of operation regarding production and supplier structures.

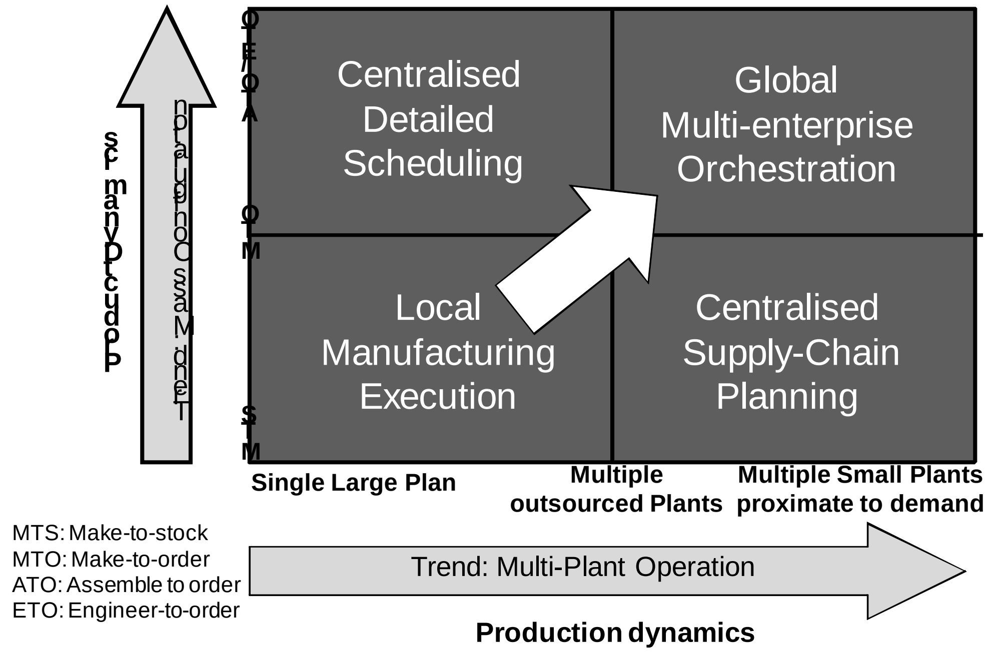


Figure 2: Trends in Operations Management (IDC 2010)

2.2. Complexity and geographical scattering

Although management is supported by ICT-Tools, without which global operation would be far more expensive and difficult, and driven by new concepts such as lean production and management, many international companies have to handle demanding structures in order to create value. Even beyond internal operations (productivity), the main purpose of today's management is the synchronisation of internal and external SCs as well as the collaborative management of complex processes (Werner 2010). While economy was once understood as the competition of companies, it is converting into a contest of SCs or even ISC. Unfortunately, complete value chains and their corresponding SCs are usually hard to capture, because of their mere complexity. Therefore, SCM and collaboration usually has to limit itself to a few levels of supply (1st tier, 2nd tier), constituting a major flaw of ISCs.

Error! Reference source not found. Figure 3 exemplifies a typical SC structure of a sophisticated product by the case example of the iPhone. It can be observed that the suppliers (1st tier) come from a large number of countries. All of these suppliers assumingly have their own individual suppliers (including SCs). Just the case of noble earths and metals as a raw product for many components in mobile phones will extend this SC network considerably, although reliable information cannot be given at this point. Nevertheless, it is most probable that some of the mentioned raw products come from places that are not represented in **Error! Reference source not found.**Figure 4, extending the supplier's SC, which is also Apple's at some point, to distant places in Africa, South America, in short, almost the entire world. In this sense, complex products produced in international SCs most likely include parts and pre-products of nearly any region of this world. The producer might be unaware of the origin of the components, because the SCM only interacts with the 1st tier and 2nd tier.

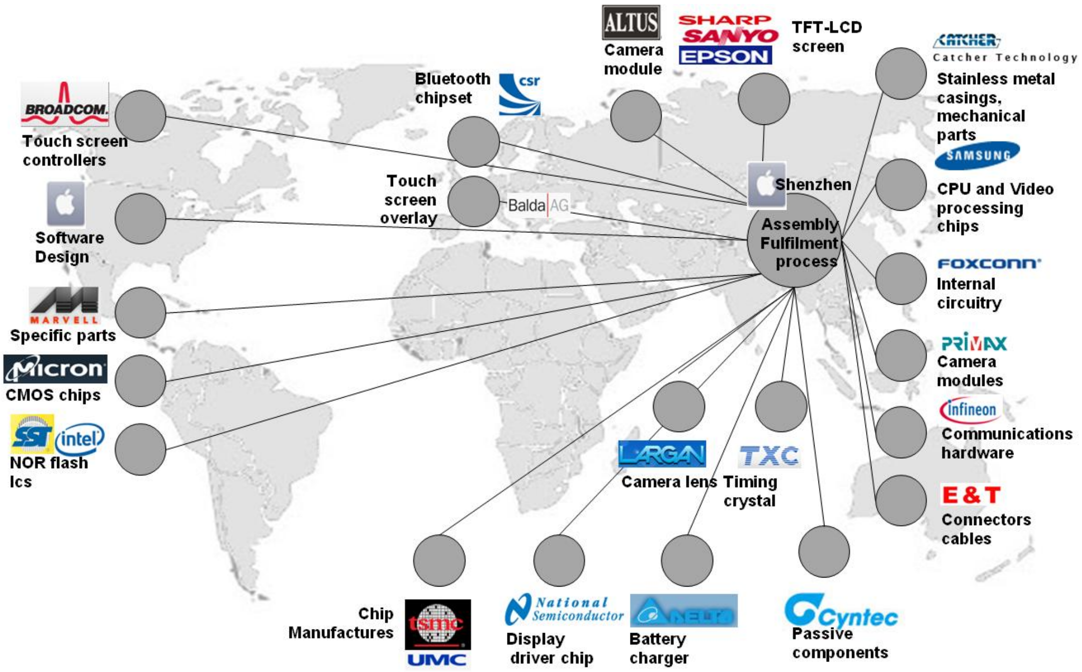


Figure 3: iPhone international supply network (compare to Abilla 2007)

2.3.Management principle

As second major tendency in international SCs besides the complexity and geographical scattering of crucial pre-products, a number of production concepts have been implemented from the very beginning of globalisation. They aim at optimising and balancing production, demand and supply in order to raise individual and SC surplus. Lean SCM and operation is probably the most important **Error! Reference source not found.** strategy to lower SC costs at the moment (IDC 2010). Like lean manufacturing, it is the intent to remove any unnecessary effort, stock, redundancies and non-value creating activities from the SC and improve the synchronisation of SCs in order to harmonise the operations (Tang and Nurmaya Musa 2011).

3. Challenges of international supply chains

It has been explain briefly, why international SCs have risen considerably in importance over the last decades. Two major tendencies have been highlighted hence: The growing complexity of SCs imposed by sophisticated products, long and tangled material flows as well as SCs on one side and the efforts to adopt lean concepts to SCs.

This chapter will outline inherent defects of international SCs against the background of recent crisis and expected developments of the global economy. Also, the trends depicted above will be reviewed critically. It will focus on highly international value chains that are organised according to lean management principles, that is, extremely efficient stock-minimising, demand-driven and specialised SCs that reduce suppliers, in order to facilitate smooth operations. Although this is probably not yet a widely-applied strategic alignment, many companies move towards this direction as described above, because it promises good market chances and profitability during undisturbed business times.

3.1. SC as a medium for the spreading of crisis

The international structure of global economy has undeniably brought prosperity to many (in the industrialised countries), enabled new products and lower prices and is therefore of great worth. Nevertheless, economical connections also constitute dependencies. Local problems can spread through the network of commercial links and even grow on their course through the system like avalanches. Extreme examples are the Black Thursday and the recently experienced financial meltdown that both caused a world-wide horror. International SC networks, as the one of the purest forms of fast and omnipresent international networks apart from financial markets, are naturally a fast conductor of problems. If SCs are organised according to the strict efficiency concepts as described above, the crisis will move up- and downstream the SC as showed in **Error! Reference source not found.**Figure 4 through loan defaults, illiquidities demand breakdown (downstream) and delivery bottlenecks (upstream) .

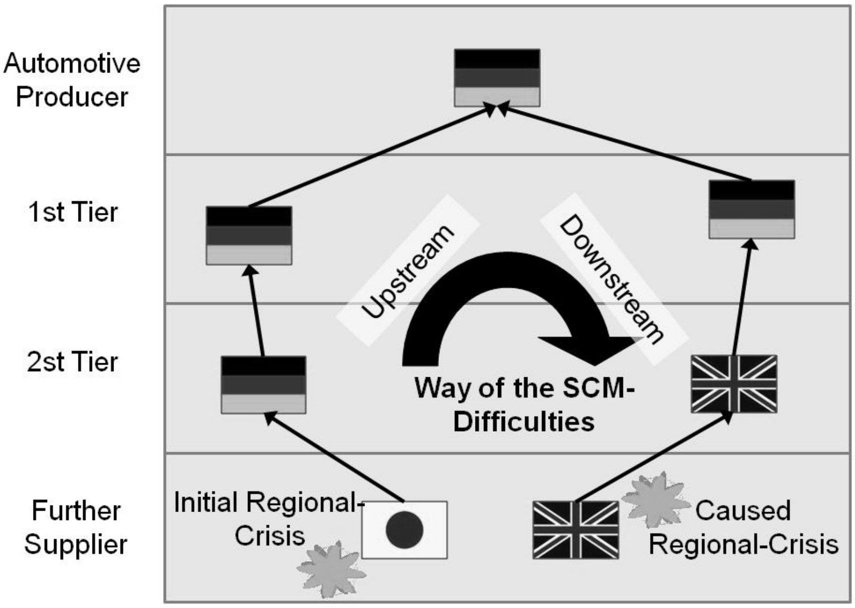


Figure 4: SCM-Difficulties

As it can be seen, problems may even occur in one specific part of the world and effect unconnected actors in distant countries or be caused by members of the SC that the end-manufacturer doesn't even know about. Two examples for these cases are the temporarily supply bottlenecks of Toyota and Apple after the devastating misfortune of Japan (Oreskovic 2011). In the IT-Section, the Federal Association for Information Technology, Telecommunications and New Media (BITCOM) announced that one out of six German companies in the high-tech sector supply have already suffered from supply problems due to the Japanese catastrophe. One out of five expects supply bottlenecks for the near future (Zeit 2011). As an example for the complexity of SCs and the implied uncontrollability during instable times, some German automotive producers may be cited. Many days after the crisis in Japan, they still didn't know if and how the situation in Japan would affect their production, because of the uncountable number of suppliers with their respective sub-suppliers and so on (Süddeutsche Zeitung 2011).

3.2. Potential external problems

It seems that the specialisation and optimisation of international SCs makes them more fragile, dependent of stability and complex. Following this idea, ongoing internationalisation-processes also entail considerable risks. If products are composed of parts from the entire world, as argued above, they also integrate the respective problems of all parts of the world to some point. Even though this might be harmless in many cases, because alternative partners exist or stocks are available, it contains considerable risk potentials for companies that produce complex products or participate in lean ISCs.

For this reason, special attention must be paid to potential crisis. In the following, some relevant problems of the near future are shortly described below. Each of them bears potential threads to local actors and therewith connected SC participants. A similar list with a different focus has been published by Tang and Nurmanya Musa (2011).

Disruptive Changes

- Financial crisis: Insolvencies, unforeseen currency fluctuations, break-down of transactions. Rather probable as the world is still recovering from the latest crisis and new ones will undoubtedly follow
- Catastrophes: A rise in number and severity of natural catastrophes has been observed and will most likely continue
- Wars: Resource-shortages will produce fierce conflicts. Also, many unresolved issues (India, Pakistan, Israel, also potential agitators like Iran, North Korea) remain
- Political Changes: As South-America shifts left, the peoples of the Maghreb claim their freedom with unknown outcome. Africa remains a continent full of conflicts and corruption. Right-shifts and euro-scepticism in Europe (England, Ireland, Netherlands, Hungary, Finland). Moreover, all countries, including those in the western world, will have to deal with severe political problems, if more disruptive changes take place or problems below are not solved

Slow changes in the environment of companies

- Peak-oil, peak-everything: Excessive and growing consumption as well as poor recyclability will cause resource-prices to peak. Among others, transportation, as one important factor for world-wide logistics, will become more expensive. Furthermore, important raw-materials will be exploited
- Climate change: Will cause a whole clutch of problems. Displaced persons, tribes and even entire nations, aggravation of water, soil and food shortage, worse catastrophes, including wars and severe conflicts

3.3. Definition of the key problems and derivation of management strategies

As a lesson learnt, regional (national) and international SCs cannot be treated and managed equally for several reasons. For example, disruptive changes that might even be of highly local character can have a major impact on entire ISCs. ISCs usually incorporate actors from various cultures, nations, business, geographical situations etc., and therewith also integrate all the respective potential problems. This is the reason why the economic crises, new policies and standards, natural disasters, strikes etc., may have a severe impact on any member of a SC, although he is not directly involved. This interconnections, combined with lean-organised SCs lead to a high SC risk potential regarding the increased occurrence and force of crises as explained. The acknowledgment of this critical situation is currently beginning to spread among scientists and the upper management. The importance to prepare organisations pro-actively for coming crises is slowly recognised, as the happy illusion of steady and unhindered economic growth and homogeneous circumstances has been proved wrong in various cases (Tang and Nurmanya Musa 2010; SCC 2010).

As one reaction to these challenges, some companies try to adopt their ISCs to this development. So far, there are hardly any real studies explaining the specific requirements of such SCs (Long, 2003, Branch 2009). Consequently, many international companies began to hire experts and analysts to address this research gap themselves. The resulting management approaches can vary substantially from one industry to another, nevertheless, some guiding principles can and will be synthesised in this work.

As a basic assumption, the problems must be met with a higher adoptability of the SC, because most disruptive changes constitute an incalculable and unpredictable thread. Spontaneous adoptability of such complex production networks is to be examined in detail, but some important strategies can already be summarised. The following overview of key trends and insights are adopted from PRTM management consultants (2010) and further concretised. All six aspects in the figure indicate the growing need to better understand, manage and optimise international SCs. The objective is always to improve the degree of preparedness of SC responsible managers to shorten reaction times.

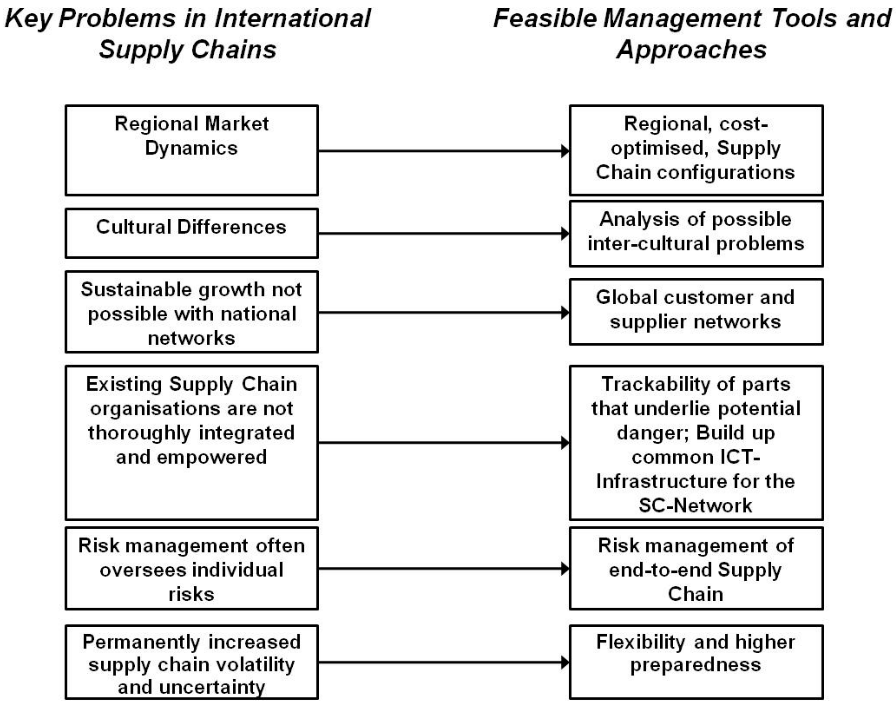


Figure 5: Challenges and Approaches of ISCM (compare to PRTM 2010)

Although **Error! Reference source not found.**Figure 5 only lists five exemplary aspects and remains on a rather general level, it procures the main requirements regarding the management approaches to be applied to crisis-prone SCs. They primarily base on the cross-company (ICT-) collaboration of various management areas, effective usage of generated data (preparedness) and an increased flexibility, which might be realised by stocks, the compilation of alternative suppliers groups or at least the engagement of various suppliers to be prepared for the deficiency of any supplier (flexibility/adoptability).

Unfortunately, these management concepts partially contradict the SC tendencies described in the beginning of the paper. For example, the cost-optimising lean-management and production as well as the internationalisation are probably the best way to generate profits during undisturbed business. This explains their recent success, but also makes these SC and therewith the entire economy more vulnerable. Considering that the 21th century will certainly be marked by the advert of many critical situations as described above, companies will soon be forced to engage more stable strategies in order to survive and prosper in the long run. The ongoing geographical expansion of ISCs additionally integrates more risk potentials in the SC.

The questions of responsible operation and management of SCs during troubled times must nevertheless be further investigated by experts from science and practice. Also, sophisticated management tools must be invested in. Although several approaches such as the SCOR model have been developed already, they do not really focus on the specific problems that companies face when dealing with uncertainties. Instead, we propose a framework which not only figures in national differences through contextualisation (Scholz-Reiter el a, 2008), but extends this framework by the consideration of multi-country dynamics in ISCs. Also, the enormous information density of ICSM must be controlled and managed better then today to keep up with reduced time to markets, allow for alternative collaboration partners in the case of disruptive changes, include tracking and tracing etc. Fortunately the advent of globally available ICT technologies such as GPS, RFID sensors or Galileo will create new opportunities for the technical support of ISCs. In summary, ICT technologies to manage information and data flows, stocks, dispatching processes etc. of complex ISCs are just arising. As they allow new ways and tools to ISCM, they must be improved and integrated as fast as possible.

Another strategy to make SCs more flexible would be an improved supply chain member management and selection. If large companies could build up a pool of reliable potential partners for all sections of the SC, SCs would become more resistant as a whole to (local) crises. For example, a conceptual tool for the short-handed partner selection has been developed by e.g. Poluha (2008) or Seifert (2007) on basis of modified SCOR-cards.

4. Summary and conclusion

Due to a comparatively peaceful period, technological advancements (ICT and production machinery), liberal governments, low transportation costs, new management principles, and continuing division of labour, the world economy has prospered over the last decades. As argued in the beginning of this paper, ISCs in combination with multi-enterprise and multi-plant production can be depicted in this context as highly sophisticated and competitive value creation networks that will be extended further in the near future.

Nevertheless, there are a series of flaws and weaknesses of ISCs that were highlighted in this paper. The fragility of current SCs was shown and it was demonstrated how problems can spread down and upstream the SC. In addition, it was deduced that complex products carry inherent risks of all those regions that contribute parts to the final product. In the following, a number of potential risks were introduced briefly. It could be concluded that the global society as well as the economy will most likely have to face severe crises in the 21th century.

Starting from the insight that current SCs are poorly prepared for times of crises, because of applied management concepts like lean management and manufacturing, key problems and new management approaches were synthesised. The increased flexibility and adoptability of SCs must be highlighted as the main challenge. A higher preparedness through extended ICT-based management tools, the installation of a completely integrated supply-chain risk management as well as an enhanced partner selection and portfolio were identified as some exemplarily management strategies to meet the demands of a more agitated world economy. Finally, two concrete management tools were listed that could rise in importance in ISCM.

IN the opinion of the authors, the behaviour and internal collaboration of ISCs must be further examined and the development of more sophisticated ICT-tools and management techniques for ISCM must be encouraged.

REFERENCES:

1. Holger, A. (2004) "Supply Chain Management: Optimierung logistischer Prozesse", Ludwigshafen: Gabler.

2. Chopra, S. and Meindl, P. (2010) "Supply Chain Management", New Jersey: Pearson.

3. Baumgarten, H. (2008) "Das Beste der Logistik: Innovationen, Strategien, Umsetzungen", Berlin: Springer.

4. Branch, A. E. (2009) "Global Supply Chain Management and International Logistics", Abingdon: Routledge.

5. Tang, O. and Nurmaya Musa, S. (2011) "Identifying risk issues and research advancements in supply chain risk management" in International Journal of Production Economics, In Press.

6. SCC-Supply Chain Councel (2010) "Key findings- Process Industry", Conference Paper, November 2th.

7. IDC Manufacturing Insights (2010) "The Changing Face of Asia Pacific Supply Chains", contribution of Chris Holmes to a SCC Conference.

8. Werner, H. (2010) "Supply Chain Management", Wiesbaden: Gabler Verlag.

9. Gehr, F. and Hellinggrath, B. (2007) "Logistik in der Automobilindustrie: Innovatives Supply Chain Management für wettbewerbsfähige Zulieferstrukturen", Stuttgart: Springer-Verlag.

10. Abilla, P. (2007) "The Apple iPhone Supply Chain", http://www.shmula.com/the-apple-iphone-supply-chain/304/, published January 18th, checked on April 24th 2011.

11. Long, Douglas. 2003. International Logistics. San Francisco: Kluwer, 2003.

12. Oreskovic, A. (2011) "Apple iPad 2 parts said squeezed by Japan quake – report", http://in.reuters.com/article/2011/03/18/idINIndia-55674920110318, published Mar 18th, checked on April 24th, 2011.

13. Seifert, M. (2007). Unterstützung der Konsortialbildung in Virtuellen Organisationen durch prospektives Performance Measurement. Dissertation at the University of Bremen.

14. Süddeutsche Zeitung (2011) "Das Problem der Lieferkette", http://archiv.sueddeutsche.de/L5F381/3969573/Das-Problem-der-Lieferkette.html, published March 17th, checked on March 19th, 2011.

15. Zeit (2011) "Elektronik-Bauteile aus Japan werden knapp", http://www.zeit.de/news-042011/18/iptc-bdt-20110418-53-29900792xml, published on April, 18th, checked on April 19th, 2011.

16. PRTM Management consultants: Global Supply Chain Trends 2010-2012. Are We Ready for recovery? Lessons Learned from the Global Recession. Management presentation at October 15, 2010. Accessible at: http://supply-chain.org/f/1-Hoole-Ready%20for%20Recovery.pdf

17. Günther, H.-O.; Mattfeld, D. C. and Suhl, L. (2007) "Management logistischer Netzwerke: Entscheidungsunterstützung, Informationssysteme und OR Tools", Berlin: Physica-Verlag.

18. Pfohl, H.-C. (2004) "Logistikmanagement: Konzeption und Funktionen", Darmstadt: Springer-Verlag.

19. Poluha, R. G. (2005) "Anwendung des SCOR- Modells zur Analyse der Supply Chain", Köln: EUL-Verlag.

20. Schieck, A. (2008) "Internationale Logistik: Objekte, Prozese und Infrastrukturen grenzüberschreitender Güterströme", München: Oldenbourg Verlag.

21. Chopra, S. and Meindl, P. (2001) “Supply Chain Management: Strategy, Planning, and Operation”, Chicago: Pearson.

22. Scholz-Reiter, B.; Daschkovska, K and Frazzon, E M (2008) “Container Logistics Networks under Context Diversity”, in Global Logistics Management. Sustainability, Quality, Risks, Berlin: Erich Schmidt Verlag.

23. Harmut, W. (2008) “Supply Chain Management: Grundlagen, Strategien, Instrumente und Controlling”, Wiesbaden : Gabler Verlag.

STRUCTURES OF LOGISTICS AND SUPPLY CHAIN RESEARCH: BIBLIOMETRIC ANALYSES OF FOUR INTERNATIONAL JOURNALS

Dr. Christoph Georgi, Dr. Inga-Lena Darkow
EBS Business School, Wiesbaden, Germany,
email. Christoph.georgi@ebs.edu;Inga-lena.darkow@ebs.edu

Professor Dr. Herbert Kotzab
Department of Logistics Management, University of Bremen
International Professor Caledonian Business School, Glasgow
email. hk.om@cbs.dk

ABSTRACT
The purpose of this paper is to explore the current intellectual foundation of logistics and supply chain research conducting a bibliometric analysis within four academic journals. With this approach we were able to identify the most influential papers, journals as well as citation streams. For the citation analysis we analyzed more than 17,000 references of 412 papers and for the co-citation analysis we further analyzed the 39 top-references with the means of MDS, Cluster- and Factor analysis.

INTRODUCTION

After more than 50 years of research in the field of logistics and about 30 years of research in the field of supply chain management (SCM), there is still a heavy discussion on the scientific character and originality of the discipline (see e.g. New, 1997; Hakansson & Persson, 2004 or Wolf, 2008). This discussion includes the development of the discipline, its research paradigm(s), its applied research methodologies (Dunn et al., 1993; Mentzer & Kahn, 1995; Kotzab, 2005) or school of thoughts (Gammelgaard, 2004; Wolf, 2006). All in all, the research character of logistics and SCM represents many facets leading to a heavy disintegration and fragmentation of the body of knowledge (Croom et al., 2000; Cousins et al., 2006; Wolf, 2008; Zsidisin et al., 2007).

However, other disciplines such as accounting, marketing, controlling, strategic management or organization science do not examine their scientific essence any longer, they rather ask the question what their intellectual basis in terms of the usage of scientific literature is (Hoffman & Holbrook, 1993; Ramos-Rodriguez & Ruiz-Navarro, 2004; Acedo & Casillas, 2005; Eom et al., 1993; Persson, 1994; White & McCain, 1998; Culnan et al. 1984; Cooper et al., 1997a). This is done by the means of citation and co-citation analysis and we think it is time to apply such methods also in the field of logistics and SCM. Some work has been done already by Carvet et al. (2008) by executing a bibliometric analysis of 33 publications published between 1995 and 2004 in order to identify the structures of SCM research (36). Georgi et al. (2010) examined in their work all articles published in the Journal of Business Logistics (JBL) between 1978 and 2008 in order to analyse the intellectual structure of JBL.

In this paper we are going to analyze more than 16,000 citations of 412 articles that were published between 2004 and 2008 in four leading academic logistics and supply chain related journals. This research was driven by the following questions:

a. Which publications were most frequently quoted within this period of time?
b. Which types of publication have the major impact on current logistics research?
c. Is it possible to identify some referencing streams or core reference areas within current logistics research?

METHODOLOGY

Sample selection

The first step of any bibliometric analysis is to identify those publications, which define the relevant scientific field (McCain, 1990). There are two possibilities to do so (36-38): a) the sample refers to those publications which are known to the researcher or b) which have been used in previous examinations. In any case, a database needs to be set up that includes these specific publications.

For the purpose of this paper and due to the explorative character of our work, we opted for the second approach (see also Ramos-Rodriguez & Ruiz-Navarro, 2004; Acedo & Casillas, 2005; Charvet et al., 2008; McCain, 1990) and searched within the EBSCO BSC database for the terms 'logistics' or 'supply chain' in the title, the abstract and in the key words. The search was limited to those articles that offered the option 'cited references available'. This led to a total of 4,356 articles published in 597 different academic journals. A first analysis of the hits showed that the *International Journal of Logistics Management* (*IJLM*), the *International Journal of Logistics: Research & Applications* (*IJL:R&A*), the *International Journal of Physical Distribution & Logistics Management* (*IJPDLM*) und the *Journal of Business Logistics* (*JBL*) were not only the most frequently quoted journals (see also logistics related journal rankings by 40-44) but also had the most relevant articles published. More than 75 % of their articles are linked to our search criteria. Contrary, the *Journal of Supply Chain Management* (*JSCM*) showed 53%, the *Transportation Journal* (*TJ*) 42% and the *Journal of Operations Management* (*JOM*) or *Journal of Production & Operations Management* (*JPOM*) 34% of their articles fitting to our search criteria.

Consequently we limited our analysis to the 17,118 citations of these 412 articles published in *IJLM*, *IJL:R&A*, *IJPDLM* und *JBL*. With the aid of a specially programed computer script, we were able to import 16,446 citations to articles, books and chapters of books. Citations to conference proceedings, working papers or similar (566) as well as all citations lacking titles (106) were not considered in our analysis. Due to citation mistakes and typos, we imported those citations as one publication if a fit of 85 % was achieved. So-called false positives were manually corrected. Publications with titles that were usually not be considered but have been used at least by 3 articles were also edited and included in the sample. Journals were identified based on their acronym, where required we made necessary corrections in order to eliminate overlapping or citation errors. After this procedure, 16,373 citations to 10,106 publications (journals, books and book chapters) and 12,660 citations to 1,194 journals were imported and analyzed (see table 1).

Table 1. Sample characteristics

Journal	Articles	Citation to publications	Cited publications	Citations to journals	Cited journals
IJLM	75	3.379	2.690	2.647	451
IJL:R&A	96	2.589	2.262	1.762	460
IJPDLM	163	6.288	4.766	4.957	708
JBL	78	4.117	2.983	3.294	434
Gesamt	412	16.373	10.106	12.660	1.194

Analysis of bibliometric information

In relation to our research questions, we analysed the data set in two steps:

- We identified the citation frequency of the 412 articles in order to recognize those publications, which majorly influence current logistics and supply chain research and looked for journal specific differences.
- Based on a co-citation analysis the most influencing publications were analysed in order to identify citation streams and core areas. The number of the publications that were considered in the citation and co-citation analysis was achieved by

looking at the Kruskal' s stress level as we were using multi-dimensional scaling of the data (Ramon-Rodriguez & Ruiz-Navarro, 2004). With this approach we identified 39 publications that were at least 16 times referenced (Kruskal's stress below 20 %; see Table 2). These 39 publications can be seen as milestones for logistics and supply chain research (Small, 1977) and were afterwards also analyzed by the means of co-citation analysis.

The following discussion refers mainly to the visual outcome of our multi-dimensional scaling. The interpretation was assisted by the results of additional factor analysis and cluster analysis.

Results

The most influencing publications and journals

The identified 39 most frequently cited publications can be grouped into 25 journal articles and 14 monographs (see Table 2). The most frequently used publication is the Christopher's (1998) textbook followed by Yin's (1985) methodological work and the conceptual paper by Mentzer et al. (2001). The journal specific comparison however revealed some interesting results. Christopher's (1998) leading position was not seen in the *JBL* but remains the top reference in the *IJLM* and *IJL:R&A.* Within the *IJLM*, we were able to identify a dominance of Christopher's work as three of the ten most cited publications are from this author. The question can be posed whether or not this result is due to the fact that Christopher was the chief editor of the journal. The dominance of Christopher within the *IJL:R&A* may be explained by the nature of the journal being the outlet for the scientific community of the UK.

Furthermore, it is surprising to see so many socio-scientific methodology papers dealing especially with quantitative and qualitative data collection and analysis. Porter (1980, 1985) was also amongst the most frequently used references, mainly in the *JBL* and *IJPDLM.* Looking at the use of standard literature within the specific journals, we saw differences between US-dominated (see *JBL*) and non-US-dominated references (see *IJLM, IJL:R&A* und *IJPDLM*).

Table 3 shows a ranking of the 30 most influencing journals including the citation to the specific journals as well as the citations within the four examined journals. The results show that logistics and supply chain knowledge stems from journals that are explicitly linked to the field (about 50 %) followed by Journal of Marketing and Harvard Business Review or other management oriented journals (32 %).

Mapping the most influencing publications

Figure 1 shows the result of our MDS analysis, where the size of the circles is in proportion to the citation frequency. Analyzing the positions of the references, we were able to recognize several citation streams and core areas.

The conceptual papers by Mentzer et al. (2001), Cooper et al. (1997b) and Lambert et al. (1998) have a noticeable central position. This group is accompanied by the work of Bechtel & Jayaram (1997) and the paper by Morgan and Hunt (1994) on trust theory as well as by the Lambert & Cooper's (2000) SCM paper.
Also very centrally positioned is a block of textbooks consisting of US-based textbooks flanked by Porter's (1980 and 1985) books on competitive strategy and competitive advantage, Simchi-Levi et al.'s (2000) SCM textbook and Christopher (1998). Simchi-Levi et al.'s (2000) position can be explained by its relation to the thematic block of "bullwhip" that is positioned at the lower end of the map. This group also includes the work by Forrester (1961).

At the right end of the map, two thematic blocks were recognized referring to supply chain design (Fisher 1997, Christopher & Towill 2002) and lean including work by the Cardiff Group. At the upper and left border areas the philosophy of science papers by

Mentzer & Kahn (1995) and Mentzer & Flint (1997), socio-scientific qualitative research (Näslund, 2002; Ellram, 1996; Yin, 1986; Eisenhardt, 1989) and socio-scientific quantitative research (Armstrong & Overton, 1977; Hair et al., 1995; Churchill, 1979; Nunnally & Bernstein, 1988) were identified. The themes logistics service/quality and critical success factor research are also linked to this block. It was interesting to see that the qualitative papers were linked to more operative issues which can be explained by the fact that logistics researchers tried to solve operative problems rather with cases than with large scale survey studies.

CONCLUSION

Based on our analysis we can answer our questions as follows. Looking at the most frequently quoted publications in our sample, we were able to identify a mix of textbooks and articles from academic journals. A closer look at the results revealed a journal specific citation pattern, not only in the choice of textbooks but also in the choice of referenced methodology papers.

We were also able to identify citation streams and citation core areas, where it was surprising to find so many general socio-scientific papers and general papers explaining the character of the field. It would be interesting to find out whether or not this is due to the fragmentation of the field where no overall valid perception of (logistics) reality exists.

However our results refer only to the four selected journals and we suggest to widen the sample including other journals also from the field of operations research and production. Some preliminary analysis has thereby shown that there is a significant split between socio-empirical and analytical work.

LITERATURE

F.J. Acedo und J.C. Casillas, "Current paradigms in the international management field: An author co-citation analysis," International Business Review, vol. 14, 2005, pp. 619–639.

F.F. Charvet, M.C. cooper, und J.T. Gardner, "The Intellectual Structure of Supply Chain Management: A Bibliometric Approach," Journal of Business Logistics, vol. 29, 2008, S. 47–73.

M.C. Cooper, J.T. Gardner, und E.B. Pullins, "A benchmark bibliometric approach to identifying the state of theory development in relationship marketing," New and Evolving Paradigms: The Emerging Future of Marketing, Dublin, S. 187-203, 1997a.

P.D. Cousins, B. Lawson, und B. Squire, "Supply chain management: theory and practice: The emergence of an academic discipline?," International Journal of Operations & Production Management, vol. 26, 2006, S. 697–702.

S.R. Croom, P. Romano, und M. Giannakis, "Supply chain management: An analytical framework for critical literature review," European Journal of Purchasing & Supply Management, vol. 6, 2000, S. 67–83.

M.J. Culnan, "Mapping the Intellectual Structure of MIS, 1980-1985: A Co-Citation Analysis.," MIS Quarterly, vol. 11, 1987, S. 341–353.

M.J. Culnan, C.A. O'Reilly, und J.A. Chatman, "Intellectual Structure of Research in Organizational Behavior, 1972-1984: A Cocitation Analysis.," Journal of the American Society for Information Science, vol. 41, 1990, S. 453–458.

S.C. Dunn, R.F. Seaker, A. Stenger, und R. Young, "An assessment of logistics research paradigms," Working Paper 93-5, Center for Logistics Research, The Pennsylvania State University, 1993.

S.B. Eom, S.M. Lee, und J.K. Kim, “The intellectual structure of decision support systems (1971-1989),” Decision Support Systems, vol. 10, Jul. 1993, S. 19–35.
B. Gammelgaard, “Schools in logistics research? A methodological framework for analysis of the discipline,” International Journal of Physical Distribution & Logistics Management, vol. 34, 2004, S. 479–491.

H. Hakansson und G. Persson, “Supply Chain Management: The Logic of Supply Chains and Networks,” International Journal of Logistics Management, vol. 15, 2004, S. 11–26.

D.L. Hoffman und M.B. Holbrook, “The Intellectual Structure of Consumer Research: A Bibliometric Study of Author Cocitations in the First 15 Years of the Journal of Consumer Research.,” Journal of Consumer Research, vol. 19, 1993, S. 505–517.

H. Kotzab, “The role and importance of survey research in the field of supply chain management,” in: Kotzab, H., Seuring, S., Müller, M. und Reiner, G. (eds.) Research Methodologies in Supply Chain Management, Heidelberg: Physica, 2005, S. 235–250.

K.W. McCain, “Mapping Authors in Intellectual Space: A Technical Overview.,” Journal of the American Society for Information Science, vol. 41, 1990, S. 433–443.

J.T. Mentzer und K.B. Kahn, “A Framework of Logistics Research,” Journal of Business Logistics, vol. 16, 1995, S. 231–250.

S.J. New, “The scope of supply chain management research,” Supply Chain Management, vol. 2, S. 15-22.

O. Persson, “The Intellectual Base and Research Fronts of JASIS 1986-1990.,” Journal of the American Society for Information Science, vol. 45, 1994, S. 31–38.

A. Ramos-Rodrìguez und J. Ruìz-Navarro, “Changes in the intellectual structure of strategic management research: A bibliometric study of the Strategic Management Journal, 1980-2000,” Strategic Management Journal, vol. 25, 2004, S. 981–1004.

H. Small, “A co-citation model of a scientific specialty: A longitudinal study of collagen research,” Social Studies of Science, vol. 7, 1977, S. 139–166.

H.D. White und K.W. McCain, “Visualizing a Discipline: An Author Co-Citation Analysis of Information Science, 1972–1995,” Journal of the American Society for Information Science, vol. 49, 1998, S. 327–355.

J. Wolf, “The Nature of Supply Chain Management Research: Insights from a Content Analysis of International Supply Chain Management Literature from 1990 to 2006,” Wiesbaden: Gabler, 2008.

G.A. Zsidisin, M.E. Smith, R.C. McNally, und T.J. Kull, “Evaluation criteria development and assessment of purchasing and supply management journals,” Journal of Operations Management, vol. 25, 2007, S. 165–183.

LITERATURE FOR CITATION AND CO-CITATION ANALYSIS

Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, *14*(3), 396–402.

Ballou, R. H. (1973). *Business logistics management*. Englewood Cliffs: Prentice Hall.

Bechtel, C., & Jayaram, J. (1997). Supply Chain Management: A Strategic Perspective. *International Journal of Logistics Management*, *8*(1), 15–34. doi: Article.

Bowersox, D. J., Closs, D. J., & Stank, T. P. (1999). *21st Century Logistics: Making Supply Chain Integration a Reality*. Oak Brook: Council of Logistics Management.

Bowersox, D. J., & Closs, D. J. (1996). *Logistical Management: The Integrated Supply Chain Process*. New York: McGraw-Hill.

Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2002). *Supply Chain Logistics Management*. New York : McGraw-Hill.

Christopher, M. (1998). *Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service*. New Jersey: Prentice-Hall.

Christopher, M., & Towill, D. R. (2002). Developing Market Specific Supply Chain Strategies. *International Journal of Logistics Management*, *13*(1), 1–14.

Churchill, G. A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research*, *16*(1), 64-73.

Cooper, M., Lambert, D. M., & Pagh, J. D. (1997b). Supply Chain Management: More Than a New Name for Logistics. *The International Journal of Logistics Management*, *8*(1), 1–14.

Daugherty, P. J., Stank, T. P., & Ellinger, A. E. (1998). Leveraging logistics/distribution capabilities: the effect of logistics service on market share. *Journal of Business Logistics*, *19*(2), 35-51.

Day, G. S. (1994). The capabilities of market-driven organizations. *Journal of Marketing*, *58*(4), 37-52.

Eisenhardt, K. M. (1989). Building theory from case study research. *Academy of Management Review*, *14*(4), 532–550.

Ellinger, A. E., Daugherty, P. J., & Keller, S. B. (2000). The relationship between marketing/logistics interdepartmental integration and performance in U.S. manufacturing firms: An empirical study. *Journal of Business Logistics*, *21*(1), 1–22.

Ellram, L. M. (1996). The use of the case study method in logistics research. *Journal of Business Logistics*, *17*(2), 93–138.

Fisher, M. L. (1997). What Is the Right Supply Chain for Your Product? *Harvard Business Review*, *75*, 105–117.

Forrester, W. D. (1961). *Industrial Dynamics*. Cambridge, MA: MIT Press.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis*. Upper Saddle River: Prentice-Hall.

Lambert, D. M., & Cooper, M. C. (2000). Issues in Supply Chain Management. *Industrial Marketing Management*, *29*(1), 65–83.

Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply Chain Management: Implementation Issues and Research Opportunities. *International Journal of Logistics Management*, *9*(2), 1–19.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). The Bullwhip Effect in Supply Chains. *Sloan Management Review*, *38*, 93–102.

Lee, H. L., & Padmanabhan, V. (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science*, *43*(4), 546–558.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., et al. (2001). Defining supply chain management. *Journal of Business Logistics*, *22*(2), 1–25.

Mentzer, J. T., & Flint, D. J. (1997). Validity in logistics research. *Journal of Business Logistics*, *18*(1), 199-216.

Mentzer, J. T., Flint, D. J., & Hult, G. T. M. (2001). Logistics Service Quality as a Segment-Customized Process. *Journal of Marketing*, *65*(4), 82–104.

Mentzer, J. T., & Kahn, K. B. (1995). A framework of logistics research. *Journal of Business Logistics*, *16*(1), 231-50.

Morgan, R. M., & Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, *58*(3), 20–38.

Näslund, D. (2002). Logistics needs qualitative research—especially action research. *International Journal of Physical Distribution & Logistics Management*, *32*(5), 321–338. doi: Article.

Nunnally, J. C., & Bernstein, I. H. (1978). *Psychometric theory*. New York: McGraw-Hill .

Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. New York: Free Press.

Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Free Press.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2000). *Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*. New York: McGraw-Hill.

Stank, T. P., Keller, S. B., & Daugherty, P. J. (2001). Supply chain collaboration and logistical service performance. *Journal of Business Logistics*, *22*(1), 29-48.

Stock, J. R., & Lambert, D. M. (1987). *Strategic logistics management*. Homewood: R. D. Irwin.

Svensson, G. (2000). A conceptual framework for the analysis of vulnerability in supply chains. *International Journal of Physical Distribution & Logistics Management*, *30*(9), 731–749.

Waller, M., Johnson, M. E., & Davis, T. (1999). Vendor-Managed Inventory in the Retail Supply Chain. *Journal of Business Logistics*, *20*, 183–204.

Womack, J. P., & Jones, D. T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Free Press.

Womack, J. P., Roos, D., & Jones, D. T. (1990). *The machine that changed the world*. New York: MacMillan.

Yin, R. K. (1985). *Case study research: Design and methods*. Beverly Hills: Sage.

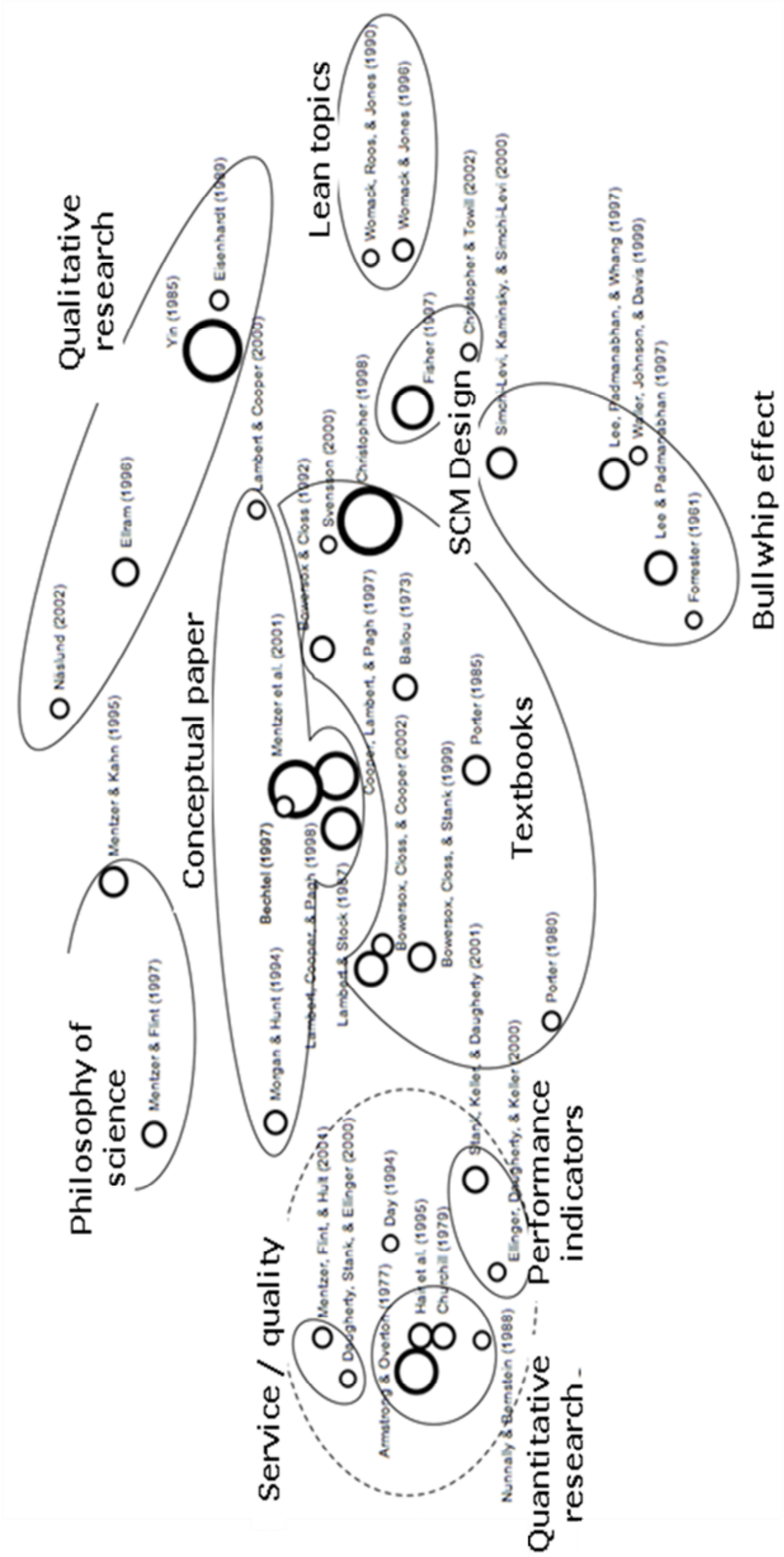
Table 2. The 39 most frequently cited publications, sorted by citation frequency

N	*Publication*	*Title*	*Journal/ Monograph*	*Total*	*IJLM*	*IJL:R&A*	*IJPDLM*	*JBL*
1	Christopher (1998)	Logistics & Supply Chain Management: Strategies for Reducing Costs and Improving Service	Monograph	59	24	15	14	6
2	Yin (1985)	Case Study Research: Design and Methods	Monograph	54	11	14	25	4
3	Mentzer et al. (2001)	Defining Supply Chain Management	JBL	50	11	6	16	17
4	Cooper, Lambert, & Pagh (1997)	Supply Chain Management: More than a New Name for Logistics	IJLM	42	11	5	11	15
5	Armstrong & Overton (1977)	Estimating Non-response Bias in Mail Surveys	JMR	40	4	4	12	20
6	Fisher (1997)	What is the Right Supply Chain for your Product?	HBR	38	11	6	13	8
7	Lambert, Cooper, & Pagh (1998)	Supply Chain Management: Implementation Issues and Research Opportunities	IJLM	37	11	5	13	8
8	Stock & Lambert (1987)	Strategic Logistics Management		31	4	7	10	10
9	Lee & Padmanabhan (1997)	Information Distortion in a Supply Chain: The Bullwhip Effect	MS	30	7	4	12	7
10	Lee, Padmanabhan, & Whang (1997)	The Bullwhip Effect in Supply Chains	SMR	28	8	3	12	5
11	Simchi-Levi, Kaminsky, & Simchi-Levi (2000)	Designing and Managing the Supply Chain	Monograph	28	1	8	12	7
12	Mentzer & Kahn (1995)	A Framework of Logistics Research	JBL	27	3	3	13	8
13	Bowersox, Closs, & Stank (1999)	21st Century Logistics: Making the Supply Chain Integration a Reality	Monograph	26	5	2	9	10
14	Porter (1985)	Competitive Advantage	Monograph	26	8	3	10	5
15	Ellram (1996)	The Use of the Case Study Method in Logistics Research	JBL	25	4	5	13	3
16	Stank, Keller, & Daugherty (2001)	Supply Chain Collaboration and Logistical Service Performance	JBL	24	6	1	6	11
17	Ballou (1973)	Business Logistics Management	Monograph	23	4	5	12	2
18	Bowersox & Closs (1996)	Logistical Management: The Integrated Supply Chain Process	Monograph	23	4	3	9	7
19	Churchill (1979)	A Paradigm for Developing better Measures of Marketing Constructs	JMR	23	1	3	9	10
20	Hair et al. (1995)	Multivariate Data Analysis	Monograph	23	5	4	7	7
21	Mentzer & Flint (1997)	Validity in Logistics Research	JBL	23	1	1	10	11
22	Morgan & Hunt (1994)	The Commitment-Trust Theory of Relationship Marketing	JM	22	3	1	10	8
23	Bowersox, Closs, & Cooper (2002)	Supply Chain Logistics Management	IJPDLM	21	4	1	6	10
24	Womack & Jones (1996)	Lean Thinking: Banish Waste and Create Wealth in your Corporation	Monograph	20	7	8	3	2
25	Bechtel & Jayaram (1997)	Supply Chain Management: A Strategic Perspective	IJLM	19	6	2	7	4
26	Mentzer, Flint, & Hult (2001)	Logistics Service Quality as a Segment Customized Process	JM	19	0	2	5	12
27	Näslund (2002)	Logistics Needs Qualitative Research—Especially Action Research	IJPDLM	18	1	4	10	3
28	Eisenhardt (1989)	Building Theories from Case Study Research	AMR	18	3	2	11	2
29	Porter (1980)	Competitive Strategy	Monograph	18	1	1	10	6
30	Ellinger, Daugherty, & Keller (2000)	The Relationship between Marketing/Logistics Interdepartmental Integration and Performance in U.S. Manufacturing Firms: An Empirical Study	JBL	17	4	1	4	8
31	Lambert & Cooper (2000)	Issues in Supply Chain Management	IMM	17	6	2	7	2
32	Nunnally & Bernstein (1978)	Psychometric Theory	Monograph	17	2	1	8	6
33	Waller, Johnson, & Davis (1999)	Vendor Managed Inventory in the Retail Supply Chain	JBL	17	4	1	7	5
34	Christopher & Towill (2002)	Developing market-specific Supply Chain Strategies	IJLM	16	7	1	5	3
35	Daugherty, Stank, & Ellinger (1998)	Leveraging Logistics Distributions Capabilities: The Effect of Logistics Service on Market Share	JBL	16	2	2	2	10
36	Day (1994)	The Capabilities of Market-Driven Organizations	JM	16	2	0	4	10
37	Forrester (1961)	Industrial Dynamics	Monograph	16	4	3	6	3
38	Svensson (2000)	A Conceptual Framework for the Analysis of Vulnerability in Supply Chains	IJPDLM	16	3	1	9	3
39	Womack, Roos, & Jones (1990)	The Machine that Changed the World	Monograph	16	5	4	5	2

Table 3. The 30 most frequently quoted journals and number of citations.

N	Cited journal	Total	IJLM	IJL:R&A	IJPDLM	JBL
1	Journal of Business Logistics (JBL)	1.206	264	98	361	483
2	International Journal of Physical Distribution & Logistics Management (IJPDLM)	960	237	122	461	140
3	International Journal of Logistics Management (IJLM)	518	188	71	151	108
4	Journal of Marketing (JM)	493	64	22	180	227
5	Harvard Business Review (HBR)	362	75	52	141	94
6	Journal of Operations Management (POM)	352	61	34	154	103
7	Management Science (MS)	324	50	50	129	95
8	Journal of Marketing Research (JMR)	294	38	17	98	141
9	Strategic Management Journal (SMJ)	266	26	19	82	139
10	International Journal of Operations & Productions Management (IJOPM)	247	76	41	105	25
11	Supply Chain Management: An International Journal (SCM:IJ)	215	74	32	84	25
12	Transportation Journal (TJ)	210	100	15	78	17
13	Supply Chain Management Review (SCMR)	186	43	17	66	60
14	European Journal of Operations Research (EJOR)	183	30	41	86	26
15	American of Management Review (AMR)	175	20	12	86	57
16	Industrial Marketing Management (IMM)	171	49	18	61	43
17	MIT Sloan Management Review (SMR)	151	36	18	57	40
18	International Journal of Logistics: Research & Applications (IJL:R&A)	142	38	46	45	13
19	International Journal of Production Economics (IJPE)	138	38	41	44	15
20	Academy of Management Journal (AMJ)	135	10	9	49	67
21	Journal of Supply Chain Management (JSCM)	120	35	13	50	22
22	Decision Sciences (DS)	114	15	19	35	45
23	Journal of the Academy of Marketing Science (JAMS)	114	16	0	35	59
24	International Journal of Purchasing & Materials Management (IJPMM)	108	32	16	40	20
25	Administrative Science Quarterly (ASQ)	93	15	6	29	43
26	California Management Review (CMR)	88	15	12	38	23
27	Journal of Business Research (JBR)	87	11	10	30	36
28	Transportation Research Part E: Logistics Transportation Review (TR:LTR)	86	36	15	16	19
29	International Journal of Production Research (IJPR)	79	18	13	42	0
30	Production & Operations Management (POM)	68	20	11	22	15

Figure 1. Structure of the 39 most influential publications on logistics and supply chain research.



TOWARDS SUPPLY CHAIN STRATEGY EXECUTION: AN AUTOMOBILE INDUSTRY CASE STUDY WITH DYADS

Sadler I and Wilden D
Victoria University

Introduction

There is a plethora of literature on formation of strategy for the operations of supply chains (for example Gattorna, 2006; Sadler & Hines, 2002). To date very little has been written on the execution of such supply chains although several works are known on the execution of business strategy (Hrebiniak, 2005). In this novel area, a case study of the start of supply chain strategy execution in dyads of a major automobile company is considered a useful addition to the literature.

This paper considers the need for supply chain strategy execution and the available knowledge in this area. The use of the Balanced Scorecard to cascade strategic objectives down the organisational hierarchy is apposite. The condensation of relevant strategy onto one piece of A3 paper is crucial for operators to comprehend. The use of a 'White Room' to temporarily remove supervisors and staff from daily operations and so permit strategic actions to be formed and reviewed is also important (reference Canadian Pacific, c.1973). Open communication between top management, middle managers and staff and with logistic service providers is also a key success factor.

The research then examines the car company situation. The company has been in the forefront of automobile quality and lean manufacture for several decades. Its central management in Japan issue wide directives which can be locally interpreted and implemented. The case focuses on the logistics of component and module supply into an Australian assembly plant. Logistics' customer is the assembly line, which should never stop, and in turn the dealers and end vehicle purchasers. A critical part of the case is the use of visual management, performance measures and regular review of progress. From the case, the extent of current knowledge of execution in the car company situation is described and the next steps required are outlined.

Knowledge of supply chain strategy execution

Supply chain management (SCM) is concerned with the tasks carried out by functional areas in the focal company and its chain partners, working within their corporate and marketing objectives to fulfil the needs of customers (Hill, 2000). The strategic task of SCM is to build a suitable resource capability and, having found out what actions will persuade customers to place orders, to put in place those actions. These tasks fall into the areas of people, information communication systems and technology (Amelsvoort, 2000). The dynamic process of strategy implementation is considered because companies have to be very flexible to rebuild supply chains in response to environmental and market conditions.

Within SCM strategy, implementation should be a rigorous process of discussing 'hows' and 'whats' the actions taken will be, and following through with the managers accountable. It includes assessing the organisation's capabilities, linking strategic actions along the value chain, synchronising the people accountable in their various disciplines, and linking rewards to outcomes (Bossidy, 2001).

Policy Deployment is a planning, implementation and review process which executes corporate strategy very effectively by ensuring that all resources work in a coordinated manner (Akao, 1991). Other existing knowledge is the Balanced Scorecard (Kaplan & Norton, 1996) which cascades strategic objectives down the organisational hierarchy. The condensation of relevant strategy onto one piece of A3 paper is crucial for operators to comprehend. Open communication between management, staff and with other departments inside the company is a key success factor.

In value chains, technology must include both physical and information communication technology since the latter is rapidly increasing the ability of management to bring relevant facts to the place and the people who take decisions. The interplay of these factors will then lead to transformational change in the operations and logistics of the enterprises involved. Moderating variables in this process are considered to be culture, relationships and leadership.

To formulate strategy for supply chains, Sadler and Hines (2002) developed a 13-step process called Strategic Operations and Logistics Planning (SOLP) which comprises, essentially, the criteria which win business and the required policies, throughout the value chain, expressed as a brief action plan. The comments from team members undertaking SOLP processes that they would appreciate continuing help with strategy implementation forms part of the impetus for the present case study. A second available paradigm is 'lean' approach to value chains, which assists chain members to develop a strategy, derive required improvements and start to implement them (Womack and Jones, 1996; Hines *et al*, 2000). A key part of the lean approach to value stream improvement is the requirement that the study team members visit each stage in the supply chain to gain both an overall appreciation of the chain and an in-depth understanding of the individual tasks which contribute to the whole.

Surveys in USA (Hrebiniak, 2005) generated a list of obstacles which prevent corporate strategy execution. which we argue is equally applicable to supply chains. Table 1, in the conclusions, shows how the case company has dealt with Hrebiniak's obstacles. The research by Hrebiniak is the main information our literature review found on the process of implementation of Operations and logistics strategy even though it is the third and crucial step, in operations and logistics strategy. Only through effective implementation will the gains envisaged in the strategy be obtained. Implementation does not appear to have been studied in this area. Because of the economic importance of implementation theory needs to be developed in this gap in knowledge.

The next section examines what has been achieved in one company.

Research Approach

Building on prior conceptual work on the execution of supply chain strategy (Sadler and Wilden, 2008), this paper uses a case study approach to investigate steps which a major car company uses to achieve such execution. The research examines a car company which has been in the forefront of automobile quality and lean manufacture for several decades. Its central management in Japan issue wide directives which can be locally interpreted and implemented. Interviews with a manager and planning documents are used to garner such information.

The case focuses on the logistics of component and module supply into an Australian assembly plant. Logistics' customer is the assembly line, which should never stop, and in turn the dealers and end vehicle purchasers.

The car company and its supply chain

The car company on which this case is based, which we call ABC Auto, is located in Melbourne, Australia, the local subsidiary of a major Japanese car manufacturer. It assembles 550 cars per day for the Australian and Middle East markets. It makes three car models in 10 main variants. ABC has 70 suppliers in Australia, mainly located in Melbourne and Adelaide, and 2 overseas supply hubs, located in Asia. Domestic sales are made through over 200 dealers on a normal lead time of three to five weeks. ABC's car assembly responds to local orders (40%) by a make-to -order strategy using just-in-time supply of parts, driven by electronic kanbans, and completion of car assembly. Middle East orders (60%) are processed in a similar manner.

Corporate and logistic goals

The corporate goal is to increase revenue by creating new markets within its core business of car design, manufacture and distribution.

The local logistics goals in the Planning Control Department, which looks after inbound transport and packaged parts inventory, are:

- '0' line stop
- '0' overflow (i.e. excess inventory)
- '0' accidents, and
- Zero defects (no damage to parts)

The organisation hierarchy is used to aim for these goals.

Organisation structure for Strategy Formation

The organisation structure in the car company uses 'Hoshin-Kanri' planning (Akao, 1991) cascaded down from one level to the next, in the following order:

- President level
- Director level
- Operating arm
- Business unit
- Department
- Section
- Team
- Person

The plan is formulated by each manager being aware of the Corporate Goal and his/her boss's goals in his/her section. The manager then answers the questions: 'What, Why, How will I achieve my goals' within the larger picture. The result is a detailed list of actions on one piece of A3 paper which are actioned and reviewed daily in a special room near the workplace called an 'Obeya' (Miller, 2010; Balle & Balle, 2005).

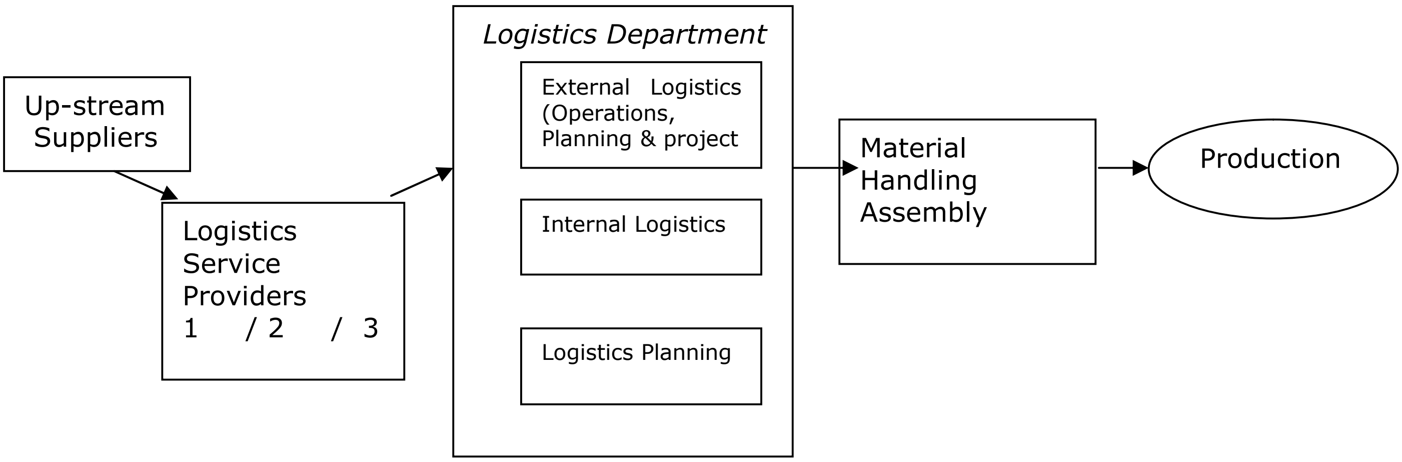


Figure 1: Part of Supply Chain investigated

Partial Supply Chain of ABC Auto

The part of the supply chain investigated at ABC Auto, from suppliers through the Logistics Department to Production is shown in Figure 1.

Reason for 'Obeya' room and structure adopted

The 'Obeya' in the Production Control Department at ABC Auto is a dedicated room located adjacent to the truck unloading bay for inbound parts. As shown in Figure 2, it has strategic, tactical and operating information displayed on time-based graphs and problem-solution sheets. The Manager, Supervisors and operating staff meet in the Obeya for a short stand-up meeting every morning. There are also meetings every week for tactical actions and every month for vision/ strategy development and implementation.

Figure 2: Logistics 'Obeya'

Advantages of the Obeya room include:

- Operators and supervisors have a place where they can step aside from the daily work pressure to reflect on current and future problems and innovative solutions
- Condition Visualisation (e.g. project schedules) in the room provide a fast, visual means of getting 'up to speed' with the current status and/ or the abnormal conditions that have arisen and require attention.
- Senior managers, suppliers and logistic service providers can, and do, visit the room to find out what has been decided, approve and add appropriate inputs.

For each area, the key performance area(s) are graphed, the issues are listed and the whole area is rated on its overall performance compared to target. The area of external logistics is broken down into Safety, Quality, Punctuality and Environment. Photos of responsible persons are provided so it is clear which staff member carries the central responsibility for each sub-area. A critical part of the Obeya is the use of visual management, performance measures and regular review of progress (Platts & Tan, 2004).
The information displayed in the Obeya is derived by individuals using spreadsheets.
Each area has a mini-Obeya which contains the information and problems particular to that area. Using these mini-Obeyas, as segments of the whole Production Control Department task, it is possible to both focus on local problems and relate them to the wider plant situation.
The current central challenge in this Department is to improve on-time truck arrivals from 94% to 97%. The current under-achievement on this overarching parameter is likely to cause line-stops. The higher target is known to be achievable as demonstrated by other plants in the car company.
The logistic service providers (LSPs) contracted to ABC Auto support the execution of ABC's logistics strategy. They visit the Obeya and add their records to complement those there. This means that the LSPs are informed of the Planning Control Department's key indicators in great detail.
A further advantage of the Obeya is that senior managers can go to different sites and see the operating and strategic information presented in the same way. This reduces the time for the managers to understand the information.

Implementation examples
An example of a change made to increase the on-time arrivals is the appointment of a particular large Australian logistics service provider, which we call LSP1. Journeys made by this company are being increased, at the expense of less accurate LSPs.
Internal and external measures were taken to build a culture in which operators and supervisors understand their goals and actively work to achieve them every day. As a

result, the key target of punctuality has been progressively improved over the last year, as demonstrated by Figure 3. Clear improvements can be seen between the period before the Obeya, the period of Obeya trial (April to September) and the period of Obeya execution (October to March, 2011).

In a similar manner to punctuality, regular attention to quality in current and future models ensures that there is *no part damage* in transit. In safety in external logistics, no accidents have occurred. The underlying theme that resonates through the improved condition is the level of 'focus' given to specific activities that underpin the wider strategy.

Before the Obeya was adopted, production & internal logistics members would make regular complaints. Now there are no complaints but PCD staff make presentations every few months to keep up the momentum of achievement.

The Obeya has lead to revolutionary management of the 'project' to introduce a new model of car. More operational planning during this project reduced the cost of packaging, in spite of more complexity & an increase in the cost of manufacture.
The wide success of the Obeya within PCD has lead to its manager being asked to facilitate a three-year plan for the whole business unit for greater application of the Obeya to realise a greater strategic benefit.

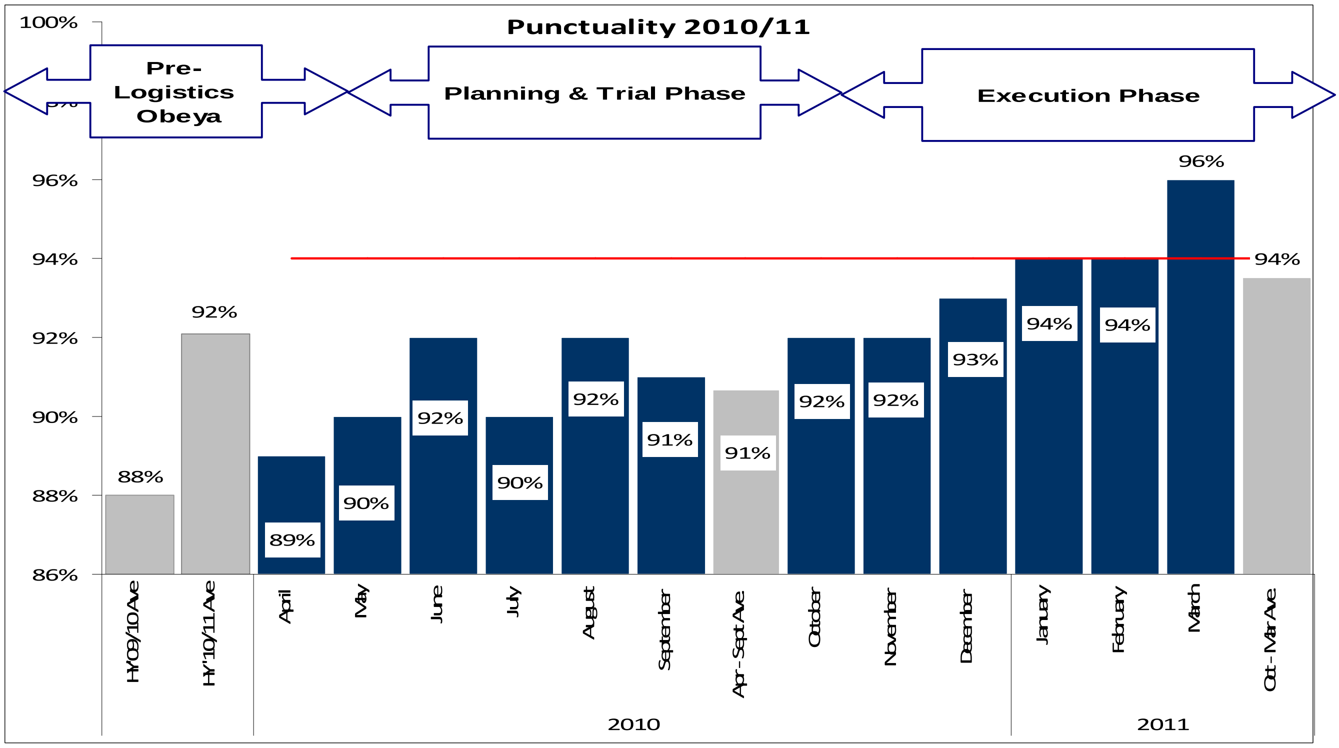


Figure 3: Increase in Punctuality achieved by Obeya

Conclusions and further work

The findings delineate the detailed actions to implant logistics strategy in the car company. The use of an 'Obeya' room to temporarily remove supervisors and staff from daily operations and so permit strategic actions to be formed and reviewed is important. The connection between the Planning Control Department and its suppliers and LSPs is a very important function of the room.
Table 1 shows how ABC's Planning Control Department has approached each of the execution obstacles identified by Hrebiniak (2005).

Currently use of the Obeya is limited to the Planning Control Department, its suppliers and LSPs and its customer, the assembly line. It is intended to extend the Obeya in the future so that it will link further downstream with ABC Auto's Marketing Department and its customers, the car dealers.

Obstacles	**Responses**
Inability to manage change effectively or to overcome internal resistance to change	Lessened by good communication.
Trying to execute a strategy that conflicts with the existing power structure	This obstacle has not been a problem within the manager's own area of responsibility. It is different in the wider application.
Poor or inadequate information sharing between individuals or business units responsible for strategy execution	There is copious information sharing in the single department level.
Unclear communication of responsibility and/or accountability for execution decisions or actions	Visualisation alleviates the problem because all operators picture how their job can contribute to the overall goal
Poor or vague strategy	Not applicable at ABC Auto, because of clear strategy communicated via Obeya.
Lack of feelings of 'ownership' of a strategy or execution plans among key employees	Senior supervisors take ownership, progressively.
Not having guidelines or a model to guide strategy-execution efforts	Not applicable at ABC Auto because they have a model.
Lack of understanding of the role of organisational structure and design in the execution process	ABC PCD started with the organisation structure and defined responses.

Table 1: Obstacles to Strategy Execution and ABC's response

This research addresses the gap of knowledge of the process of execution of supply chain strategy. The findings can be used by other manufacturing operations to improve the extent of strategy execution along the supply chain.
Because of rapid change in customer preferences in a globalised world, companies need to continually adjust their logistic strategies. This paper supplies some actions which can be used to quickly rebuild supply chains to current customer and business strategy requirements.

REFERENCES

Akao Y, 1991, *Hoshin Kanri*, Productivity Press, Portland.

Amelsvoort P van, 2000, *The Design of Work and Organisation : The Modern Sociotechnical Systems Approach*, ST-GROEP, Vlijmen, Netherlands.

Balle F & Balle M, 2005, 'Lean Development', *Business Strategy Review,* Vol. 16, Issue 3, 17-22.

Bossidy L, 2001, 'The Job No CEO should delegate', *Harvard Business Review*, Vol. 79, Issue 3, 46-9.

Canadian Pacific, personal communication circa 1973.

Gattorna J, 2006, *Living Supply Chains*, Harlow, UK: Prentice-Hall.

Hill T, 2000, *Manufacturing Strategy: Text and Cases*, Palgrave.

Hines P, Lamming R, Jones D, Cousins P & Rich N., 2000, *Value Stream Management*, Pearson Education, Harlow, UK.

Hrebiniak L G, 2005, *Making Strategy Work*, New Jersey, USA: Wharton School Publishing.
Kaplan RS and Norton DP, 1996, 'The Balanced Scorecard: Translating Strategy into Action', *Harvard Business Review,* 74(1), *75-85*
Miller J, 2010, '5 Ways the Obeya (Big Room) increases profit' viewed at www.gembapantarei.com/2010/08/5 on 2/2/11.
Platts K and Tan KH, 2004, 'Strategy Visualisation: Knowing, Understanding and Formulating, *Management Decision,* 42(5), 667-76.
Sadler I and Hines P, 2002, 'Operations Planning process for manufacturers with a supply chain focus: concepts and a meat processing application' *Supply Chain Management; An International Journal*, 7(4): 225-41.
Sadler I and Wilden D, 2008, *The process of execution of supply chain functional strategy: a review of knowledge of content and process,* Proc. of the 13th International Symposium on Logistics, Bangkok.
Womack JP & Jones DT, 1996, *Lean Thinking*, New York, USA: Simon & Schuster,.

THE RELATIONSHIP BETWEEN PRODUCT DESIGN AND SUPPLY CHAIN MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

Amirreza Hashemi, Tim Butcher
Applied Logistics Research Group, RMIT University, Melbourne, Australia

ABSTRACT
This paper presents a systematic review of extant literature to establish what research has considered product design factors in the supply chain management domain. In so doing, this research aims to identify the limitations of this current body of knowledge and opportunities for further research.

Peer-reviewed journal articles published between 2000 to the end of 2010 from the top 10 supply chain management journals as defined by Menachof et al. (2009) are reviewed using pre-defined Boolean search terms. The articles found directly relevant to this research are evaluated to identify an emerging body of research highlighting the significant impact of product design on supply chain strategies in different industries. This relationship is most commonly seen in fast growing industries with short product life cycles. With ever-shortening product lifecycles comes the need to design and redesign supply chains accordingly. Yet to date the relationship between product design and supply chain management is not widely debated in the scholarly literature. We therefore propose further research.

Keywords: Product design, Supply chain, Integration, Concurrent engineering.

INTRODUCTION:
This research is motivated by the ever-increasing array of consumer products available in today's global markets. The drive to maintain availability of multiple stock keeping units across multiple locations is alone a ceaseless challenge faced by retailers and their suppliers. Yet this is just the beginning of their concerns. It is not merely enough to maintain those existing products. They too must manage the introduction of new products to their supply chains to satisfy consumer demand for the latest fashions and innovations. New product development lead times in sectors such as apparel, electronics and automotive have shrunk considerably in recent years in response to global competition and consumer demand. The consequence of increased new product development is greater supply chain complexity, with new products being introduced to global distribution networks at increasing frequency; plus the added complication of withdrawing obsolescent products that have reached the end of their now very short lifecycles.

So with high frequency new product introduction now being a key differentiator in certain sectors, the integration of product design with supply chain management is now critical. A clear link between supply chain management and product design should therefore be evident in the scholarly supply chain management literature. Here we investigate recent research via a systematic literature review to establish extant knowledge of product design factors in the supply chain management domain. In so doing, we aim to identify opportunities for further research.

RESEARCH METHOD:
The systematic literature review method is adopted. This research examines product design factors in the supply chain management domain, so focuses only on articles published in supply chain management peer reviewed periodicals published (in English). The top ten periodicals for research usefulness in terms of the quality of article, their impact on discipline and their value to the research were selected (Menachof et al. 2009). A Boolean search of those periodicals' volumes dated from January 2000 to December 2010 was conducted using the the resources defined in table 1 to capture current thinking. The keywords employed in the Boolean string were: 'product design'

and 'supply chain'. 353 search results were captured. These required refinement by reviewing article titles and abstracts. Those articles whose abstracts did not refer directly to the relationship between product design and supply chain management were excluded to produce 126 papers. Upon reviewing these 126 papers a total of 36 papers were selected for final analysis (see table 1).

Each article was reviewed and coded. Each article was classified based on the author(s) name, journal and year of publication, type of the industry investigated, research methods and sample sizes, research approach, supply chain aspects studied, key finding and research limitations. Four common themes for discussion were extracted from the articles reviewed. Namely: product design and supply chain integration; product, process and supply chain concurrent engineering; supplier involvement in product design; and product design and the supplier interface. Some authors were found to cover more than one of those themes. These are discussed below.

Table 1: SC-Product design Interface articles published in selected journals

Journals	Database	Initial Search	First Refinement	Final Papers
JBL*	Proquest	25	14	1
IJPDLM	Proquest	60	34	4
IJLM	Proquest	28	9	1
JOM	Science Direct	151	53	12
SCMR	EBSCO	10	4	2
TJ	Proquest	3	0	0
HBR	EBSCO	2	1	0
MS	Proquest	36	16	1
TR	Science Direct	6	1	0
SCMIJ	Proquest	83	24	3
IJOPM	Proquest	141	43	12
	Total	**545**	**199**	**36**

*JBL:Journal of Business Logistics, IJPDLM: International Journal of Physical Distribution and Logistics Management, IJLM: International Journal of Logistics Management, JOM: Journal of Operations Management, SCMR: Supply Chain Management Review, TJ: Transportation Journal, HBR: Harvard Business Review, MS: Management Science, TR: Transport Research: Part E, Logistics and Transportation Review, SCMIJ: Supply Chain Management: An International Journal, IJOPM: International Journal of Operations and Production Management.

PRODUCT DESIGN AND SUPPLY CHAIN INTEGRATION:

A lack of integration, communication and information sharing between partners will constrain the responsiveness of a supply chain. A lack of integration of product design with upstream suppliers causes continuity and quality of supply issues. And a lack of downstream integration can result in inaccurate market knowledge and failed new product launches (Khan & Creazza 2009). Integrating product design with supply chain management is therefore critical to achieving core business objectives. Adopting a design centric perspective across an extended enterprise is therefore recommended, but will require a cultural shift and an improved understanding of the design process interface with other key functions (Khan & Creazza 2009).

There is concurrence in extant literature that integrating the product design function with the conventional business functions associated with supply chain management effective supplier integration will result in improved supply chain performance. Proposed benefits include: precise, accessible and distributable product information (Huang et al. 2010); advance notice of design changes (Swink & Song 2007); a more flexible design process (Abecassis-Moedas 2006); improved product performance and conformance (Abecassis-Moedas 2006; Swink & Song 2007). Yet it is suggested that much of the extant research focuses merely on optimizing product availability at launch, and a more holistic perspective of the product lifecycle be adopted (Hoek & Chapman 2006).

For such integration to be successful, effective communication and cooperation among new product development project participants is essential. An increase in organizational complexity is likely (Swink & Song 2007). Hence the integration of product design with supply chain management should be strategic (Stavrulaki & Davis 2010), with senior product development managers at the helm (Koufteros et al. 2002) of cross functional teams (Khan & Creazza 2009). This results in changing boundaries in the value chain via knowledge transfer (Abecassis-Moedas 2006). Designers' appreciation of the retail function will grow, and vice versa to design products that better meet market requirements. Vertical integration is found an effective strategy. In the fashion sector, some retailers control product design, shrinking time-to-market, increasing supply chain responsiveness and reducing risk (Khan et al. 2008).

Nevertheless, while supply chain integration has a positive impact on market performance, it does not necessarily result in customer satisfaction (Swink et al. 2007). And although it positively affects overall business performance, it does not influence manufacturing competitiveness at plant level. Internal knowledge sharing (e.g. product-process integration) does however. This is contextualized when we consider that product architecture must compliment the level of vertical integration (Novak & Eppinger 2001; Fixson 2005). In-house production is preferred when products are complex. Product modularity combined with the relocation of value adding activities and a reduced supplier base will decrease the level of vertical integration necessary (Pero et al. 2010).

PRODUCT, PROCESS AND SUPPLY CHAIN CONCURRENT ENGINEERING:
Product design has a significant impact on supply chain cost (Cargille & Bliss 2001). And pressures to reduce production and delivery lead-times have raised the level of mutual dependencies in the product development process and the necessity for strategic coordination (Hong et al. 2009).The level of integration proposed requires a concurrent engineering approach (Koufteros et al. 2002; Khan & Creazza 2009; Hong et al. 2009).

A concurrent approach will enhance the speed and confidence of decision-making at the product design stage to increase product profitability (Cargille & Bliss 2001), and can result in more consumer-focused processes (Kincade et al. 2007). This is particularly so in volatile markets with intense competition. Simultaneity increases responsiveness but brings with it complex interdependencies between the product, process and supply chain. The proposed solution to complexity is the three-dimensional concurrent engineering (3DCE) approach; a model first suggested by Charles Fine in his 1998 book Clockspeed (Fixson 2005). This model suggests that the traditional approach of matching product with process should also include supply chain variables. This should be further supported by decision support systems to manage the complex array of decision variables (Singhal & Singhal 2002; Blackhurst et al. 2005; Huang et al. 2005; Closs et al. 2008).

However, 3DCE is only considered appropriate for descriptive studies. For analytical studies the model needs refinement. Its over-emphasis on product modularity and under-emphasis on product lifecycle are among its limitations (Voordijk et al. 2006). 3DCE is currently conceptual, deterministic and mostly based on two rather than all three aspects of 3DCE (Ellram et al. 2007). Yet the proposed benefits of simultaneously coordinating the design and distribution of products make the pursuit of a practical 3DCE solution worthwhile. Concurrent engineering can mass customization (Kincade et al. 2007). For example, apparel product development activities need not be linear; so can be achieved simultaneously to support postponement of finishing processes. Any concurrent engineering approach should though be consistent with the level of product novelty (Singhal & Singhal 2002).

SUPPLIER INVOLVEMENT IN PRODUCT DESIGN:
Early supplier involvement in concurrent engineering is recommended to optimise coordination between product, process and supply chain design (Koufteros et al. 2002; Khan & Creazza 2009). A lack of product design manager involvement in supply chain processes and is cause of many supply chain problems (Khan et al. 2008b). Involving those who will produce the designed products will mitigate supply chain risks (Khan & Creazza 2009); enable quality checks before products reach the market (Koufteros et al. 2002); raise the commitment of partners (Koufteros et al. 2002); clarify requirements before incurring high development costs (Koufteros et al. 2002; Labro 2006); increase supply chain flexibility by reducing product development lead-time (Stevenson & Spring 2009); reduce product complexity and costs while increasing manufacturability and

quality (Stevenson & Spring 2009; Doll et al. 2010); improve supply chain resilience (Stevenson & Spring 2009); improve the buyer-supplier relationship (Shin et al. 2000). However, creating such close ties will limit supply chain reconfiguration if necessary (Stevenson & Spring 2009).

Besides involving manufacturing outsources at an early stage, it is further argued that logistics providers should also be consulted. The aim of which would be to minimize logistics costs (Zacharia & Mentzer 2007), and optimize inventory planning (Hoek & Chapman 2006). Consequently the required supply chain responsiveness discussed above is achievable. This obviously fits with the 3DCE debate discussed.

The implications of involving multiple stakeholders in product design do however have its pitfalls. The time stage at which suppliers are involved and the responsibility they are afforded requires careful consideration (Petersen et al. 2005). As well as inter-organisational compatibility, there are also transnational concerns expressed. Research investigating Italian supplier integration into US and Japanese automotive product design highlights that the level of involvement is not necessarily transferable (Zirpoli & Caputo 2002). Each buyer-supplier relationship is therefore different. When involving multiple suppliers in the design process, an overarching coordination strategy is essential to manage the various relationships (Hong et al. 2009). Specific considerations for a coordination strategy include product modularity, product complexity, technological uncertainty, and supplier's technical capability.

PRODUCT DESIGN AND SUPPLY CHAIN INTERFACE:
How the interface between product design and the supply chain functions is critical. Product technology is perpetually updating, so a supply chain organisation structure must be strategically aligned with product design (Blackhurst et al. 2005; Sebastian K. Fixson 2005; Closs et al. 2008). Integrated design is associated with a more coordinated supply chain. This relationship is mediated by four factors: new module/component development; technological knowledge leakage and creation; project team size; and supply chain efficiency (Lau et al. 2010a). The proposed design centric supply chain concept offers a 4Cs approach to work organisation at the interface: product range *champions*, *cross-functional* teams, *co-location* of concurrent design teams and *cooperation* across the extended enterprise (Khan & Creazza 2009).

Product design should be considered by supply chain professionals to be more than merely a creative task. Good product design will mitigate supply chain risk (Omera Khan et al. 2008b) and minimise conflicts of interest (Cargille & Bliss 2001). Choices regarding materials, suppliers and manufacturability will determine a range of supply chain costs (Ayers 2003). The design–supply chain interface(s) must therefore be considered holistically. For example, coordination of product design engineers and purchasing agents leads to improved supply chain performance (Novak and Eppinger 2001). Both functions play a major role in make-or-buy decisions. Integrating platform product decisions, manufacturing process decisions, and supply sourcing decisions is critical to achieving supply chain flexibility (Huang et al. 2005).

Product modularity is a key enabler of outsourcing, co-development and therefore competitive advantage (Howard & Squire 2007; Jacobs et al. 2007; Swink et al. 2007; Antonio K.W. Lau et al. 2010b). The interdependent relationship between product and supply chain design will however have trade-offs between integrality and modularity. Different levels of modularity and integration will suit different products (Fine et al. 2005). Product complexity influences supply chain complexity (Caridi et al. 2010; Pero et al. 2010b). Perpetual product innovation impacts supply chain structure, causing constant supply chain reengineering (Caridi et al. 2010). This is compounded by increasing product variety and modularity (Pero et al. 2010b). Effectively, more variables are being introduced into supply chains at an increasing velocity and frequency as a consequence of the integration and concurrency discussed.

Thinking beyond individual products, a general rule of thumb is that the manufacture of complex products should remain in-house and less complex products outsourced (Novak and Eppinger 2001). Build-to-order strategies enabled by product modularity will complement such outsourcing decisions. Hence mass customization is possible to achieve the requisite responsiveness (Gunasekaran & Ngai 2005). Product portfolio complexity mediates between environmental drivers and business performance, but this is not sufficiently explored in extant literature. There is a need to develop metrics to measure the dimensions of product complexity and their effects on supply chain performance (Closs et al. 2008).

DISCUSSION:

In examining the discussed body of knowledge, we aim to identify what methods are employed, themes in the research findings, and gaps in the knowledge to identify the limitations of this current body of knowledge and opportunities for further research.

A significant issue identified in the literature is the lack of adequate studies investigating the influence of product design on supply chain management (Khan & Creazza 2009), with many on sourcing decisions (e.g Novak and Eppinger 2001). We therefore explored this issue by identifying the research methodologies used and therefore their adequacy. We divided the articles into three categories: review, empirical and constructive.

Seven review studies were identified. Those studies mostly concentrate on coordination and integration of product design with supply chain strategies. Most offer conceptual frameworks to improve supply chain and product design performance. The proposed frameworks are not yet reported as having been empirically tested.

21 empirical studies were identified. Those are either case studies (11) or quantitative surveys (10). 12 of those empirical studies were conducted in single industries mostly in apparel, high technology and automotive. The remainder, with two exceptions, conducted their research regardless of industry sector. Most studies were also conducted in developed countries such as the UK and US. There is general a lack of research in cross-country and cross-sector research to account for different demand patterns and product complexities in different industries.

Six constructive studies were also identified. Those articles use secondary data from industry to offer mathematical and quantitative models to simulate optimal product design with supply chain solutions. Most of those studies concentrate on product modularity and the sourcing decisions of supply chains, which demand customization for different particular industries.

There is some concurrence in the literature, which led us to identify the four themes discussed above. The reviewed literature generally agrees on how to integrate product design with supply chain management, and the benefits to be gained. With increasing dependence on the extended enterprise, supplier involvement as early as possible in the design process will better prepare the supply chain for new product introductions. As lead-times shrink and frequency of new product development increases, supply chain complexity increases in line with increasing product architecture complexity and proliferation. The 3DCE concept offers a vision of cross-functional teams from across the extended enterprise collaborating concurrently. The key issue is that it remains a concept.

Product modularity is also discussed in the reviewed literature as a key enabler of contemporary quick response supply chain management. Apportioning responsibility for design, production and delivery of product modules to suppliers is observed as good practice. How this capability would be enhanced by 3DCE remains to be researched. Yet, a certainty is that a holistic view of product design integrated with supply chain management is necessary. Hence product, process and supply chain should be developed concurrently to maximize availability and reduce risk. This offers significant opportunities for further research to extend the supply chain concept.

CONCLUSIONS AND FURTHER RESEARCH:

This paper provides a systematic review of recent studies investigating the integration of product design into supply chain management research. The purpose of this research was to identify the main research streams in this area and delineate the current and previous approaches regarding product and supply chain design.

In conclusion this body of research emphasizes the influences of product design on supply chain management and the potential benefits of improved profitability, quality, performance, flexibility, and reduced cost, risk and complexity. Research in this domain is increasing, with the number of articles published in 2000 being one, to six in 2010, but in general this area is under-explored. There has however been a recent recognition of the complexity of the phenomena. In the earlier articles reviewed, product design and supply chain management was treated as a binary relationship. Yet now more researchers highlight the multi-dimensional nature of the relationship, and propose a holistic approach.

One possible explanation for this area of critical research not yet gaining momentum could be that the reviewed articles are written from a range of different theoretical standpoints (e.g. marketing, engineering, operations management). Consequently the required holistic approach has not yet been adopted by the researchers. Each study investigates either product design (e.g. modularity) or supply chain (e.g. coordination), while other characteristics have been identified that mediate the relationship between product design and supply chain management. This is where opportunities for further research lie. There is a need for further research regarding the impacts of different product characteristics on different aspects of supply chain management to understand the full extent of the complexity involved before integrating concepts such as 3DCE can be fully implemented. Reductionist approaches are insufficient. This particular preliminary research will be extended by modeling and evaluating the supply-side and demand-side antecedents of supply chain complexity.

We recognize that our research is limited to a select range of periodicals where one would expect to find research in this area published. It is likely that further research on the product design – supply chain management interface has been conducted. This is merely a snapshot of this particular body of knowledge, but it reflects what has been achieved to date and the need for further research. It is clear that large-scale cross-disciplinary research is essential to gain holistic solutions proposed.

REFERENCES:

Abecassis-Moedas, C. (2006) 'Integrating design and retail in the clothing value chain: An empirical study of the organisation of design', *International Journal of Operations & Production Management*, 26(4), 412–428.

Ayers, J.B. (2003) 'Costs: Getting to the Root Causes', *Supply Chain Management Review*, 7(6), 24–31.

Blackhurst, J., Wu, T. & O'Grady, P. (2005) 'PCDM: a decision support modeling methodology for supply chain, product and process design decisions', *Journal of Operations Management*, 23(3-4), 325–343.

Cargille, B. & Bliss, R. (2001) 'How supply chain analysis enhances product design', *Supply Chain Management Review*, 5(5), 64–74.

Closs, D.J., Jacobs, M.A., Swink, M. & Webb, G.S. (2008) 'Toward a theory of competencies for the management of product complexity: six case studies', *Journal of Operations Management*, 26(5), 590–610.

Doll, W.J., Hong, P. & Nahm, A. (2010) 'Antecedents and outcomes of manufacturability in integrated product development', *International Journal of Operations & Production Management*, 30(8), 821–852.

Ellram, L.M., Tate, W.L. & Carter, C.R. (2007) 'Product-process-supply chain: an

integrative approach to three-dimensional concurrent engineering', *International Journal of Physical Distribution & Logistics Management*, 37(4), 305-330.
Fine, C.H., Golany, B. & Naseraldin, H. (2005) 'Modeling tradeoffs in three-dimensional concurrent engineering: a goal programming approach', *Journal of Operations Management*, 23(3-4), 389–403.
Fixson, S.K. (2005) 'Product architecture assessment: a tool to link product, process, and supply chain design decisions', *Journal of Operations Management*, 23(3-4), 345–369.
Gunasekaran, A. & Ngai, E.W.T. (2005) 'Build-to-order supply chain management: a literature review and framework for development', *Journal of Operations Management*, 23(5), 423–451.
Hoek, R.V. & Chapman, P. (2006) 'From tinkering around the edge to enhancing revenue growth: supply chain-new product development', *Supply Chain Management: An International Journal*, 11(5), 385-389.
Hong, Y., Pearson, J.N. & Carr, A.S. (2009) 'A typology of coordination strategy in multi-organizational product development', *International Journal of Operations & Production Management*, 29(10), 1000–1024.
Howard, M. & Squire, B. (2007) 'Modularization and the impact on supply relationships', *International Journal of Operations & Production Management*, 27(11), 1192–1212.
Huang, T.T.A., Stewart, R.A. & Chen, L., (2010) 'Identifying key enablers to improve business performance in Taiwanese electronic manufacturing companies', *International Journal of Operations & Production Management*, 30(2), 155–180.
Huang, G.Q., Zhang, X. & Liang, L. (2005) 'Towards integrated optimal configuration of platform products, manufacturing processes, and supply chains', *Journal of Operations Management*, 23(3-4), 267-290.
Jacobs, M., Vickery, S.K. & Droge, C. (2007) 'The effects of product modularity on competitive performance: Do integration strategies mediate the relationship?', *International Journal of Operations & Production Management*, 27(10), 1046–1068.
Khan, O., Christopher, M. & Burnes, B. (2008) 'The impact of product design on supply chain risk: a case study', *International Journal of Physical Distribution & Logistics Management*, 38(5), 412-432.
Khan, O. & Creazza, A. (2009) 'Managing the product design-supply chain interface: Towards a roadmap to the "design centric business', *International Journal of Physical Distribution & Logistics Management*, 39(4), 301-319.
Kincade, D.H., Regan, C. & Gibson, F.Y. (2007) 'Concurrent engineering for product development in mass customization for the apparel industry', *International Journal of Operations & Production Management*, 27(6), 627–649.
Koufteros, X.A., Vonderembse, M.A. & Doll, W.J. (2002) 'Integrated product development practices and competitive capabilities: the effects of uncertainty, equivocality, and platform strategy', *Journal of Operations Management*, 20(4), 331–355.
Labro, E. (2006) 'Is a focus on collaborative product development warranted from a cost commitment perspective?', *Supply Chain Management: An International Journal*, 11(6), 503–509.
Lau, A.K., Yam, R.C. & Tang, E.P. (2010a) 'Factors influencing the relationship between product modularity and supply chain integration. *International Journal of Operations & Production Management*, 30(9), 951–977.
Lau, A.K., Yam, R.C. & Tang, E.P. (2010b) 'Supply chain integration and product modularity: An empirical study of product performance for selected Hong Kong manufacturing industries', *International Journal of Operations & Production Management*, 30(1), 20-56.
Menachof, D.A., Gibson B.J. Hanna, J.B. & Whiteing, A.E. (2009) 'An analysis of the value of supply chain management periodicals', *International Journal of Physical Distribution & Logistics Management*, 39(2), 145-165.
Novak S. & Eppinger, S.D. (2001) 'Sourcing by Design: Product Complexity and the Supply Chain', *Management Science*, 47(1), 189-204.
Pero, M., Abdelkafi, N., Sianesi, A. & Blecker T. (2010) 'A framework for the alignment of

new product development and supply chains', Supply Chain Management: An International Journal, 15(2), 115-28.
Petersen, K.J., Handfield, R.B. & Ragatz, G.L. (2005) ‘Supplier integration into new product development: coordinating product, process and supply chain design’, *Journal of Operations Management*, 23(3-4), 371-388.
Shin, H., Collier, D.A. & Wilson, D.D. (2000) ‘Supply management orientation and supplier/buyer performance’, *Journal of Operations Management*, 18(3), 317–333.
Singhal, J. & Singhal, K. (2002) ‘Supply chains and compatibility among components in product design’, *Journal of Operations Management*, 20(3), 289–302.
Stavrulaki, E. & Davis, M. (2010) ‘Aligning products with supply chain processes and strategy’, *The International Journal of Logistics Management*, 21(1), 127-151.
Stevenson, M. & Spring, M. (2009) ‘Supply chain flexibility: an inter-firm empirical study’, *International Journal of Operations & Production Management*, 29(9), 946–971.
Swink, M., Narasimhan, R. & Wang, C. (2007) ‘Managing beyond the factory walls: effects of four types of strategic integration on manufacturing plant performance’, *Journal of Operations Management*, 25(1), 148–164.
Swink, M. & Song, M. (2007) ‘Effects of marketing-manufacturing integration on new product development time and competitive advantage’, *Journal of Operations Management*, 25(1), 203–217.
Voordijk, H., Meijboom, B. & de Haan, J. (2006) ‘Modularity in supply chains: a multiple case study in the construction industry’, *International Journal of Operations & Production Management*, 26(6), 600–618.
Zacharia, Z.G. & Mentzer, J.T. (2007) ‘The role of logistics in new product development’, *Journal of Business Logistics*, 28(1), 83-110.
Zirpoli, F. & Caputo, M. (2002), ‘The nature of buyer-supplier relationships in co-design activities: the Italian auto industry case’, *International Journal of Operations & Production Management*, 22(12), 1389–1410.

AN EXPLORATION INTO THE VALUE OF TIME AND COST INFORMATION IN THE MALAYSIAN FOOD SUPPLY CHAIN

Linda Whicker
Nottingham University Business School, University of Nottingham Malaysia Campus, Jalan Broga, Semenyih, 43500, Selangor Darul Ehsan, Malaysia
linda.whicker@nottingham.edu.my
Telephone: 0060 (0)3 8924 8251
Fax: 0060 (0)3 8924 8019

ABSTRACT
This paper explores the value of two main areas of information used in supply chain management (SCM) decision-making in the Malaysian food supply chain: time and cost information. In order to qualitatively assess the value of time and cost information in this environment, a series of semi-structured interviews were held with key employees in a company case study. The results are discussed in relation to the literature. This paper will argue that through analysing supply chains from a time and cost perspective simultaneously, the amount of useful information available to supply chain managers' increases thereby enabling them to make better decisions. The insights gained from this study will be used to demonstrate how the company can enhance its understanding of time and cost information using globally recognised tools and the potential impact this will have on the SCM performance. Implications include the impact on the modernisation and restructuring of the local food industry in Malaysia into a more dynamic supply chain network.

INTRODUCTION
Management decision-making is a challenging task, given the complexity of business operations today and the difficulties involved in people management. Coupled with this, it is believed that SCM more than any other business function can contribute significantly to a firm's sales and revenue by influencing or managing its costs (Burt et al. 2010). This paper is concerned with decisions made in the area of SCM. Sound decision-making here ensures the effective delivery of products and services to customers. Therefore, it is essential that supply chain managers have access to good quality information. If any information is incomplete then the quality of managers' decisions can be impaired; resulting in excess inventory, poor quality, late deliveries, poor customer service levels and excess cost. This paper explores the value of two main areas of information used in SCM decision-making: time and cost information. Time and cost information provide key metrics for business performance. The focus for this paper is to study the value of these two types of information in an industrial context. The focal company was established within the last five years, as a private but government-linked establishment. One of the major objectives of the company is to contribute to the Malaysian food industry with its recent innovations, advanced practices and technologies in order to increase the competitiveness of the entire industry not only within Malaysia but also globally. This is consistent with the 10th Malaysia Plan that was launched in June 2010, which clearly articulated one of the growth areas as being the high value-added services, indicating that the agricultural sector is envisaged to grow by 3.4% per annum. The company supplies a wide range of fresh fruits and vegetables both locally and internationally: including; pineapples, rock melons, bananas, lettuce, tomatoes and papayas, which it sources from farms in various locations around Malaysia.

LITERATURE REVIEW
There are many definitions for a supply chain and absolute consensus remains elusive (Braziotis & Tannock, 2010). Lambert *et al*. (1998) state that a supply chain is a network where a focal company has a horizontal position connected via different types of links with tiers of suppliers (upstream) and customers, from initial suppliers to end-consumers (downstream). A food supply chain has a high level of dynamic collaboration of potential partners that must achieve effective performance (Vorst et al. 2005). Due to

globalisation and advances in technology, the food supply chain is characterised by intensive globalisation. This trend complicates the food networks and forces all members to reconsider their places, roles and value propositions in order to achieve an improved common performance. Within each network, SCM decisions are made on three levels; strategic, tactical and operational. A strategic level decision would be Push vs. Pull for supply chain design, a tactical decision has a shorter time horizon and could include, determining inventory policies. The final level is operational, i.e., day-to-day decisions like, which inventory fills which order, order fill dates, etc. (Chopra & Meindl, 2007). Many of these decisions require cost information and/or time information. In other cases the impact of making the decision will result in a cost (product cost, inventory cost, etc.) or a time component (delivery time, process time, etc.). Consequently, sound decision-making needs to be supported by appropriate and robust performance metrics. There is a growing body of literature that supports the development of supply chain performance metrics (Gunasekaran, 2004, Chopra, 2007, Thakkar, 2009, Bigliardi, 2010, Burt, 2010). The general consensus is that metrics should cover the whole remit of supply chain processes in the areas of plan, source, make and deliver as illustrated by the SCOR Model (Supply Chain Council, 2011). The new frameworks therefore cover measurements from the traditional functional perspective to a wider more integrated supply chain perspective.

Over the last two decades, time-based information has been used to improve businesses in terms of efficiency, effectiveness and responsiveness to customer demands. This has been possible due to the development of a number of tools and techniques such as Business Process Engineering (Hammer & Champy, 1993), Just-in-Time (Bicheno, 1991) and Lean Manufacturing (Womack *et al*., 1990) that use time as a key measure for business analysis. Time is an essential measure in business because it not only provides an indicator of efficiency of individual activities, but also effectiveness in responding to customer demands, whether it is the supply of existing products or the development of new products. Improving time also has indirect effects on other measures. For example, quality can be improved by allowing an earlier detection of faults. Furthermore, time is universally understood and can be readily measured, serving as a unifying element common to all facets of the system. One of the key aspects of using process time information is the ability to account for the total time in processes which include both activities (tasks where work is being done in the process) and non-activity time (when nothing is happening in the process). This should add value to the decision-making process as both of these elements have a cost associated with them.

Costing approaches in business have traditionally focused on transactions rather than products and processes. They focus on the allocation of costs to functions and departments within a business and not on reflecting the actual cost of making and delivering a product for a particular customer. These costing techniques are most appropriate within manufacturing for high volume, repeatable orders. Champions of contemporary costing techniques have questioned the emphasis of traditional methods and their suitability to measure performance in terms of customers, products and activities. Activity Based Costing (ABC) methods try to identify true cost drivers by allocating costs to activities (Kaplan & Anderson, 2004). This should aid managers into making better decisions. In these methods the overhead costs are apportioned depending on the resources they consume and are not solely related to volume. The approach is product-based and was initially designed for calculating costs only (Gunasekaran et al., 2001). Today, ABC as well as providing an accurate cost for each individual product also produces further diagnostic capabilities in the form of identifying where and how the most important costs occur in the production process for a specific product. The essence of this costing method is to match direct costs to specific activities to give a more realistic picture of where the true costs lie. ABC can contribute to SCM in a number of ways by: highlighting product and cost profitability, increasing accountability and ownership of supply chain costs, improving performance measurement by comparing similar activities in different locations (Kaplan & Anderson, 2004).

THE RESEARCH QUESTION

The focus for this paper is on *what* time and cost information is present in the supply chain and *how* it is used for decision-making. Case studies are particularly useful for answering what and how research questions. The research explores the value of such information. In this case, value is defined as the level of understanding of the time and cost information within the supply chain of a company. A set of objectives were subsequently developed:

1. Identify the current decisions company managers make with respect to time and cost and the measures used, i.e. what does the information look like?
2. Explore examples of specific issues regarding the quality and availability of this information, or the lack of it in the company, i.e. what are the current problems?
3. Highlight the gaps in the information and suggest how to overcome those using a combination of tools and techniques, i.e. what information is missing and how could it be provided?

The scope focuses on operational as opposed to strategic decisions for one supply chain in the food industry in Malaysia. The proposition being tested is that a greater understanding of time and cost information will enable managers to make better decisions.

METHODOLOGY

The approach taken for this research was an in-depth case study. A level of mutual trust had been developed during the preceding months of this study that ensured unique access to the highest levels of management in the focal company and therefore exposed the researcher to significant tacit knowledge. The interviewees represented a range of functions from within the business in order to gain alternative viewpoints and perspectives about the research subject matter. The unit of analysis was the supply chain of the focal company. A senior management representative was nominated by the company to assist in the research. He was instrumental in developing the list of interviewees, arranging the interviews, validating the responses and clarifying discrepancies and misunderstandings of the researcher. This also ensured any issues due to cultural aspects were recognised and addressed. There were nine interviews performed over a four-month period during 2010. Each interview typically took 2 hours and was carried out in the interviewees' place of work. The interview questions were developed from the literature and information gathered at preliminary meetings with the company. The interviews were transcribed and returned to the interviewees for validation to ensure there were no misunderstandings.

Other forms of data collection included direct observations (for a total of one week, at two different locations), a review of current company documentation and the keeping of field notes. The data analysis followed a sequential process starting with the identification of common themes in the data aligned with the research objectives. This was tabulated in a data display that enabled a full view of the data set arranged systematically. A textual explanation of the case was developed using pattern-matching. Quotes are used to illustrate particular aspects of the analysis.

The findings are discussed in relation to the existing literature. Reliability and validity of the results was addressed using two methods: the joint reflection of the data collected and interpreted between the researcher and the nominated company representative; and the feedback gained from the presentation of the results to the company CEO and other senior managers. This latter contributed particularly to the credibility of the research process, a vital element in qualitative studies (Naslund, 2010).

RESULTS/ANALYSIS

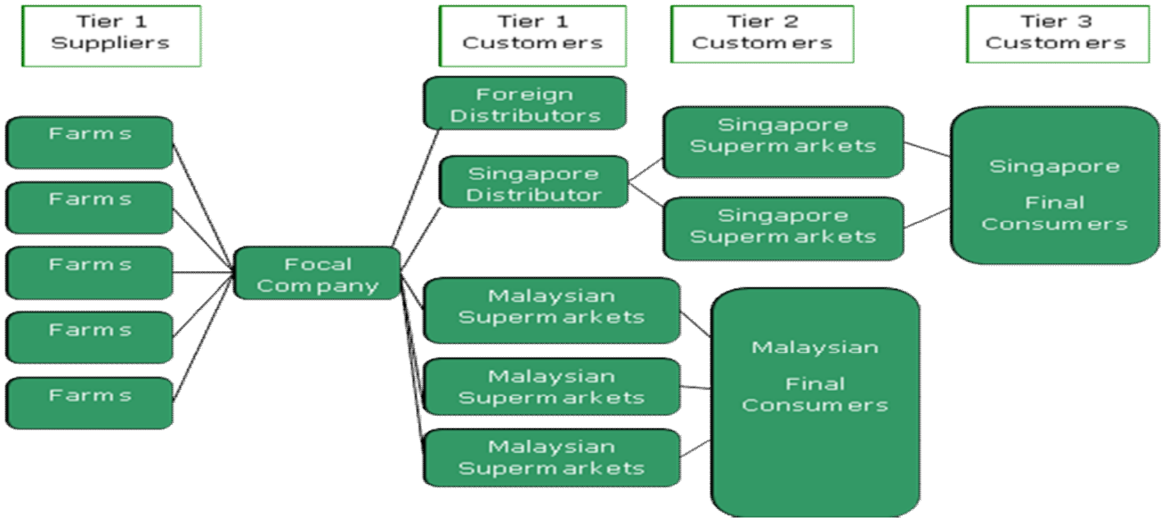


Figure 1: The Focal Company Supply Chain

The focal company incorporates the integrated supply of fresh fruits and vegetables that are sourced from owned and contracted farms and the spot market in many regions of Malaysia and India and delivered to retailers within Malaysia and to distributors around the world, Figure 1. The supply chain is dominated by the primary members: the focal company's own departments/units, farms, processing plants and also external suppliers of the produce and services. The external farms play a significant role in sourcing of produce. Most of the produce (85-90%) is sourced from contracted farms and spot markets. In three regions the company has processing plants to consolidate and process the products. Generally, the supply chain has the following production flow: harvesting, consolidation, processing and packing of the produce into 10 kg carton boxes in the plants, transporting them either abroad for export or to the main distribution centre, inventory management, final packing into small packs according to the customer requirements and final delivery to the supermarkets within Malaysia and to the distributors abroad. The supply chain does not have fully integrated software support, but elements of best practice in software systems.

Tables 1 & 2 represent the findings from the interviews that have been consolidated into 12 categories. The first four categories provide evidence for the level of knowledge held by the interviewees regarding SCM. The scaling used in Category 2 and 12 is based on a simple numerical scale with equal distances. So for Category 2, a score of 0 indicates a lack of experience, while a score of 3 indicates extensive experience in SCM practice according to the researcher's evaluation. Likewise, the same approach is used for Category 12 with respect to the availability of the data. On average, the interviewees have over 2.5 years experience in a 5-year old company with varying degrees of experience in SCM dependent on their job role. All are familiar with supply chain terminology using key common terms consistent with the literature (Lambert & Cooper, 2000, Chopra & Meindl, 2007). There is however, almost no awareness of specific supply chain metrics, as depicted in the current literature (Supply Chain Council, 2011, Thakkar *et al*., 2009) in the company. The interviewees who responded positively to this question inevitably provided examples that were more functionally oriented than supply chain integrated. Another indicator of supply chain awareness is Category 9 - *who was affected by the decisions made*. The interviewees clearly perceived a limited degree of scope and awareness of the implications of their decisions. The answers varied between one or two departments (most common response) to many, and generally showed a limited extent of the impact to the decision-making.

		Interviewee			
	Research Areas	A	B	C	D
	Designation	Head of OM	Head of SCM	Head of Sales	Business Analyst
1	Co. experience	4 years	3 years	1 ½ years	3 years
2	SCM experience (Scale=0 to 3)	2	3	1	2
3	Use SC terminology	Yes	Yes	Yes	Yes
4	Articulate Co. SC strategy	Yes	Yes	Yes	Yes
5	SC metrics	No	No	No	No
6	Decisions	Adjusting timing plans and operational costs	Timing of supplies 3PL contracts and budget setting	Timing of supplies Annual sales plan	Weekly cost analysis
7	Time-based metrics	Output/hour Mc perf/hour	On time delivery Order fulfillment	Order fulfillment	None
8	Cost-based Metrics	Cost/kg	Labour cost Variances to budgets	Cost/customer CSL	Order fulfillment/ customer Order fulfillment/SKU CSL, Cost/kg
9	Who affected by your decisions	Marketing Logistics	Quality	Production Quality	Sends cost analysis report to Board
10	Waste is ….	'Product with no retail value'	'Product we can't sell'	'Lost sales' 'yield'	'yield'
11	Issues regarding cost and time information	Not measure turnaround time or delivery time Hard to benchmark costs Availability of supply info.	Info flow between Co. and 3PL Sales orders uncertainty for packing	Info regarding out of spec product in SC Availability of supply info.	Forecast data inaccurate Not collecting historical data Availability of supply info.
12	Availability of correct data (Scale= 0 to 3)	2	1	1	1

Table 1: Data Display of Results from Interviews I

The next part of the research was to investigate the actual decisions that the managers in the company make day-to-day and to identify the common performance metrics. Furthermore, examples of past problem areas with respect to the information in the decision-making process is explored more thoroughly. This should give an insight into the difficulties faced by managers in trying to make the right decision. Typical decisions for the interviewees involved in SCM showed that; as expected, the most frequent types of decisions concerned delivery times and operational costs. This was supported by the metrics used (Category 6, 7 & 8). This is consistent with the literature; prior to the 1990's, performance measurement was predominantly functionally focused (Gunasekaran *et al*., 2001, Bigliardi *et al*., 2010). The two most common measures were order fulfilment and cost/kg across the responses. By using more specific questioning during the interviews it was discovered that order fulfilment meant 'in full' not 'on time in full' as practiced by many companies today in America and Europe. The key measure for cost was cost/kg of product and so was volume based and followed traditional accounting methods. The focal company has yet to incorporate alternative methods like ABC or Process Costing that are more relevant for management decision-making. There was little awareness of these methods amongst the interviewees. In analysing the issues described with respect to time and cost information (Category 11), a number of common themes emerged:

1. Limited access to up-to-date information for decision-makers
2. Incorrect information in the supply chain (supported by low score in Category 12)
3. Speed of information flow too slow between supply chain members

4. Incomplete set of relevant performance metrics

The interviewees articulated several issues and implications of the lack of information and also the time pressures they faced, i.e., “there is no luxury of time to waste in this industry”. There was a general frustration felt by the interviewees that improvements could be made, yet a lack of confidence and time to pursue the changes needed.

	Interviewee				
	E	F	G	H	I
	Head of HR	VP SCM SC Planning	Head of Marketing	GM Operations	Head of ICT
1	2 ½ years	2 years	3 years	1 ½ years	1 year
2	0	3	0	1	1
3	Yes	Yes	Yes	Yes	Yes
4	Yes	No	Yes	Yes	Yes
5	Not yet	Customer returns Inv. Levels Load util. in trucks	No	Inv. Levels % pack vs. order Order fulfillment Quality	Not sure
6	New work teams to look at delivery times and conversion costs	Delivery times Timing of supplies Inventory levels	Time to market plans and budget costs	Sourcing Farm mangt. Data collection process and content Operational cost	Data processing times Operational & system costs
7	Cycle time for recruitment	Buffer inv. level in days	Time to capture new markets	Tonnes/day	Availability of server as % downtime Times for inputting data
8	Developing conversion cost in co. Cost of operations in HR	None	Cost of operations in Marketing	Cost/kg Yield/hectare	Cost of systems Cost of operations in ICT
9	All	Sourcing, Production Sales, Control Centre 3PL	Sales Production	Logistics	All departments
10	‘yield’	‘yield’	‘Difference between what market wants and what we can deliver’	‘not in spec.’	‘yield’ ‘non-sales’
11	Understanding lack of skills/ knowledge and training accordingly	Speed of info. flow current systems 1 to 2 days behind Not collecting historical data Availability of supply info.	Understanding of target costing Availability of supply info.	Flow of strategy from top-down Poor communication by farmers ‘no luxury of time to waste’ in this industry	Sourcing and demand data not linked No info on efficiency of resources like training, ICT support
12	2	0	1	2	1

Table 2: Data Display of Results from Interviews II

DISCUSSION

The employees in the focal company demonstrated a good awareness of SCM through their answers. This directly contrasts with a recent study on Malaysian manufacturing companies that found a general “lack of awareness of SCM” by managers (Manzouri *et al*., 2010). In this study, the managers were reluctant to instigate changes to improve SCM because they were unconvinced by the outcome. Another study concurs with the latter view that Malaysian industry is slow at implementing SCM with a number of significant barriers to its adoption: the most important being a lack of support from top management (Awheda et al., 2010). Therefore, the focal company in this study demonstrated a more advanced SCM awareness than others in Malaysia and a readiness to pursue SCM best practice. This is consistent with one of its strategic goals.

The decisions relating to time and cost were revealed to be more functionally oriented. The company uses basic relevant metrics for time in varying degrees of detail in the supply chain. For example, it does not measure and record late deliveries to its distribution centre, which can impact on customer delivery times. The capability for taking further time-based measures is within the company but not exercised at present. As mentioned previously, the cost metrics were not supply chain oriented. Collecting cost data is very dependent on identifying and acquiring the correct data from the key fact holders. Cost is an historical measure, which has to be consumed before it can be measured. It often proves difficult to measure accurately as indicated by the common themes that emerged from this study. The interviewees' answers clearly indicated problems with incomplete and incorrect information as well as delays in accessing the correct data. This in turn, impacted on the quality of their decisions; resulting in excess inventory, poor quality, late deliveries, poor customer service levels and excess cost.

The current situation could therefore be improved by adopting methods that capture more accurate time and cost data. It has already been suggested that time can be directly applied to supply chain analysis enabling the identification of problems and significant detail about the supply chain processes. This information can then be used to identify the relevant costs. This would also require a greater understanding of waste, as defined by the Lean paradigm, as being all non-value adding processes. Currently, the focal company has a very narrow view of waste which limits the decision-making. Consequently, this paper proposes that improvements to the quality and availability of time and cost information could be gained by implementing a method that combines time and cost analysis of supply chain processes (Whicker et al, 2009, Kaplan & Anderson, 2004). ABC has been further developed however; it has not been shown to identify the costs, or the causes, of non-active process time, for example, when a product is waiting for an activity to be performed upon it at the individual product level. This waiting time leads to an increase in the total production time and subsequently an increase in the total supply chain time. If this time information can be provided concurrently with the corresponding costs, then managers should have more accurate information with which to make decisions.

Implications/Limitations

Deep & Dani (2010) suggest that currently there are seven future trends in the food supply chain, namely increased dependency on technology, increased interdependence between companies, united approach to standards, traceability, training, credence attributes, changing consumer habits and greener logistics. The Malaysian Government through the focal company is trying to encourage a step change in the national food industry so that companies are ready for these challenges. Having a better understanding of time and cost information could clearly enable Malaysian supply chain managers to improve their decision-making and therefore the overall performance of their supply chains. This in turn, would influence the modernisation and restructuring of the food industry in Malaysia into a more dynamic supply chain network. Further work in this area therefore includes applying time and cost methods to the focal company and assessing any improvements obtained. This could also be diversified into other industrial sectors. Limitations include the limits of using a single case study for generalising the findings and possible researcher bias.

CONCLUSIONS

This paper has explored the value of two main areas of information used in SCM decision-making: time and cost information through an in-depth company case study. From the literature, it was found that time-based methodologies have a proven ability to demonstrate valuable time information and ABC has also established a good performance to date in being able to provide useful costing information to managers. This paper has suggested that analysing supply chains from a time and cost perspective simultaneously, should increase the amount of useful information available to supply chain managers' thereby enabling them to make better decisions. The insights which the interviewees' responses revealed will allow changes to be made as to how the company can enhance its understanding of time and cost information using globally recognised tools, potentially to improve its SCM performance.

REFERENCES

Awheda A, Rahman M N A & Arshad H (2010) "Key Factors Influencing the Effectiveness and Efficiency of Supply Chain Management in Small and Medium Enterprises (SMES) in Malaysia", Proceedings from 15th ISL, Kuala Lumpur, 4-7 July.

Bicheno J (1991) "Implementing JIT", IFS Publications

Bigliardi B & Bottani E (2010) "Performance Measurement in the Food Supply Chain: a Balanced Scorecard Approach", Facilities, 28, 5/6, 249-260

Braziotis C & Tannock J (2010) "Towards the expended enterprise: clarifying paradigms and concepts in supply chain management" Proceedings from the 15th ISL, Kuala Lumpur, 4-7 July

Burt D, Petcavage S & Pinkerton R (2010) "Supply Management", New York: McGraw Hill

Chopra S & Meindl P (2007) "Supply Chain Management", Pearson Prentice Hall, USA.

Deep A & Dani S (2010) "Configuring next generation food supply chains: a risk perspective" Business School, Loughborough University, Loughborough. Proceedings of the 15th ISL, Kuala Lumpur, 4-7 July

Gunasekaran A, Patel C & McGaughey R E (2004) "A Framework for Supply Chain Performance Measurement", International Journal of production Economics, 87, 333-347

Gunasekaran A, Patel C & Tirtiroglu E (2001) "Performance Measures and Metrics in a Supply Chain Environment", International Journal of Operations & Production management, 21, 1/2, 71-87

Hammer M & Champy J (1994) "Re-engineering the Corporation a Manifesto for Business Revolution", Nicholas Brealey.

Kaplan R S & Anderson S R (2004) "Time-Driven Activity-Based Costing", Harvard Business Review, 82, 11, 131-138

Lambert D M, Cooper M C & Pagh J D (1998) "Supply chain management: implementation issues and research opportunities" International Journal of Logistics Management, 9, 2, 1-19

Lambert D M & Cooper M C (2000) "Issues in Supply Chain Management", Industrial Marketing Management, 29, 65-83

Manzuori M, Rahman M N A, Arshad H & Ismail A R (2010) "Barriers of Supply Chain Management Implementation in Manufacturing Companies: a Comparison between Iranian and Malaysian Companies", Journal of Chinese Industrial Engineers, 27, 6, 456-472

Naslund D, Kale R & Paulraj A (2010) "Action Research in Supply Chain Management – A Framework for Relevant and Rigorous Research", Journal of Business Logistics, 31, 2, 331-355

Stalk G & Hout (1990) "Competing Against Time; How Time-Based Competition is Reshaping Global Markets", Free Press, USA

Supply Chain Council (2011), SCOR Model, http://supply-chain.org/scor, (Accessed on 26/4/11)

Thakkar J, Kanda A & Deeshmukh S G (2009) "A Supply Chain Performance Measurement Framework for Small and Medium Scale Enterprises", Benchmarking: International Journal, 16, 1, 702-723

Vorst van der J G A J, Beulens A J M & Beek van P. (2005) "Innovations in logistics and ICT in food supply chain networks", in Jongen W M F & Meulenberg M T G, Innovation in agri-food systems, (Eds), 245-292, Wageningen: Wageningen Academic Publisher

Whicker L, Bernon M, Mena C & Templar S, (2009) "Understanding the Relationships between Time and Cost to Improve Supply Chain Performance", International Journal of Production Economics, Amsterdam, October, 121, 1, 641-650

Womack, Jones and Roos (1990) "The Machine that Changed the World", Rawson Associates, Macmillan

RESEARCH ORIENTATIONS OF THE SELECTED SUPPLY CHAIN MANAGEMENT PERIODICALS: A CRITICAL REVIEW

Shams Rahman, Ahmad Abareshi, Sujak Bakir, Shafiq Ahmad
School of Business IT and Logistics,
RMIT University, Melbourne, Victoria 3000, Australia,
shams.rahman@rmit.edu.au

ABSTRACT

Purpose of the paper
The purpose of this study is to (i) review articles in selected supply chain periodicals for their contribution to research in various supply chain issues, (ii) classify the literature based on a suitable classification scheme, leading to some useful insights into supply chain research and (iii) develop a framework for some future research directions.

Design/methodology/approach
This paper provides a comprehensive assessment of 1828 articles in logistics & supply chain management, published between 1995 and 2009. Five logistics & supply chain periodicals are included in this study; they are, in alphabetical order: International Journal of Physical Distribution and Logistics Management (IJPDLM), Journal of Business Logistics (JBL), Journal of Operations Management (JOM), Supply Chain Management: An International Journal (SCMIJ) and The International Journal of Logistics Management (IJLM).

Findings
The results show that the highest number of articles was published in theme synchronise supply chain, whereas, the lowest number was published in the security theme. The top five themes are synchronise supply chain, IT in supply chain, distribution and transportation, supply chain design and procurement and supply management which constitute about 63% of the total articles reviewed. The results also show that the percentage increase in publication is relatively higher in themes belonging to the emerging theme category compared to the classical theme category over the review period. Over 51% of the articles were published in the context of North America, whereas only one article was published in the context of African countries. The results also show that the percentage increase in publication is relatively higher in the context of developing and emerging economies compared to developed economies.

Research limitations/implications
Our analysis takes into account the publication of articles in only five major periodicals.

Practical implications
By analysing different themes of supply chain literature this paper provides a research agenda to guide future research.

What is original/value of paper
Although there has been a few review research conducted in some specific areas of supply chain management, taking a much broader view this paper provides findings on fifteen supply chain themes which helped developing a framework for future research directions.

Keywords: Critical review, Research orientation, Supply chain management, Supply chain periodicals

INTRODUCTION

The application of supply chain principles and management concepts has made a significant impact both in academic and industrial circles over the last two decades. The growing number of articles on various issues of supply chain systems in the literature is an indication of the importance of supply chain management and of its role in improving the competitiveness of organizations. To date many attempts have been made to identify critical success factors in supply chain management, investigate relationship between logistics strategy and business processes, identify drivers behind successful strategic supplier alliances, assess the impact of TQM practices on logistics and supply chain performance, measure the effect of supply management orientation on supplier performance, examine the role of communication in supply chain management, and investigate the impact of information technology on supply chain capability.

Today's global business environment is characterised by expanding foreign markets, comprehensive information networks, improved transportation, higher customer expectations, and high wage-rates. Effective and efficient supply chain management offers a means of gaining competitive advantage in an environment increasingly characterised by fierce competition and uncertainty. The purpose of this study is to (i) review articles in selected supply chain periodicals for their contribution to research in various supply chain issues, (ii) classify the literature based on a suitable classification scheme, leading to some useful insights into supply chain research and (iii) develop a framework for some future research directions.

The paper is organised as follows: In the next section, the methodology and the various parameters on which literature is being reviewed have been discussed. In the 'Trend and pattern analytical results' section, collected data have been presented in tabular and graphical forms and discussed. The paper ends with a conclusion section highlighting future research directions.

METHODOLOGY

Time horizon, journal and article selection

In this paper we provide a comprehensive assessment of 1828 articles in logistics & supply chain management, published between 1995 and 2009. Five logistics & supply chain periodicals are included in this study; they are, in alphabetical order: International Journal of Physical Distribution and Logistics Management (IJPDLM), Journal of Business Logistics (JBL), Journal of Operations Management (JOM), Supply Chain Management: An International Journal (SCMIJ) and The International Journal of Logistics Management (IJLM).

Selection of supply chain themes

We selected seven logistics and supply chain texts published in English between 1998 and 2010; they are Lambert, Stock and Ellram (1998), Coyle, Bardi and Langley Jr. (2003), Ballou (2004), Wisner, Leong and Tan (2005), Harrison and van Hoek (2008), Chopra and Meindl (2010), and Christopher (2010). We scanned the contents of these texts (Table 1) and clustered them into fifteen supply chain themes (Table 2). These are; Demand management, Procurement & supply management, Inventory management, Distribution/transportation, Managing material flows, Synchronise supply chain, IT in supply chain, Supply chain design, Global supply chain, Performance and service, Risk in supply chain, Event logistics, Supply chain sustainability, Security in supply chain, and Quality management in supply chains. These themes falls into two broad themes: classical and emerging. Some of the themes belonging to the classical theme category include inventory management, forecasting and demand management, distribution and transportation and the themes such as supply chain security, risk, green and sustainability belong to the emerging theme category.

Lambert, Stock and Ellram (1998)	**Wisner, Leong and Tan (2005)**	**Coyle, Bardi & Langley Jr. (2003)**	**Chopra and Meindl (2010)**	**Harrison & van Hoek (2008)**	**Christopher (2010)**	**Ballou (2004)**
• The role of logistics	Supply chain management: an overview	Supply chain management	Understanding the supply chain	Logistics and SC	Logistics, SC and competitive advantage	Business logistics/ supply chain - a vital subject
• Customer service	Purchasing management	Dimensions of logistics	SC performance: achieving strategic fit	Putting the customer first	Logistics customer value	Logistics/SC strategy and planning
• Logistics information systems	Creating and managing supplier relationship	Demand management and customer service	SC drivers and Metrics	Value and logistics costs	Measuring logistics cost and performance	The logistics/ SC Product
• Inventory concepts	Strategic sourcing	Procurement and supply management	Designing the distribution network	Managing logistics internationally	Creating the responsive supply chain	Logistics/SC customer service
• Inventory management	Demand forecasting	Global logistics	Network design in the supply chain	Managing the lead-time frontier	Strategic lead time management	Order processing and information systems
• Managing materials flow	Aggregate planning and inventory management	Managing inventory flow	Designing global SC networks	SC Planning and control	The synchronous supply chain	Transport fundamentals
• Transportation	Enterprise resource planning systems	Warehousing decisions	Demand forecasting	The agile SC	Managing global pipeline	Transport decisions
• Warehousing	Process management: JIT and TQM	The transport system	Aggregate planning	Integrating the SC	Managing risk	Forecasting SC requirements
• Materials handling, computeriz-ation, and packaging	Domestic and international transportation	Transportation management	Planning supply and demand	Purchasing and supply relationships	Overcoming the barriers to SC integration	Inventory policy decisions
• Purchasing	Customer relationship management	Logistics relationships and 3PL	Managing economies of scale: cycle inventory	Logistics future challenges and opportunities	Entering the era of network competition	Purchasing and supply scheduling decisions
• Global logistics	Facility location decisions	Logistics & supply chain information systems	Safety inventory			The storage and handling system
• Organising for effective logistics	Service response logistics	Supply chain performance measurement	Determining optimal level of product availability			Storage and handling decisions
• Methods to control logistics performance	Supply chain process integration	Network design and facility location	Sourcing decisions			Facility location decisions
• Supply chain management	Performance measurement	Supply chain finance	Transportation			The network planning process
• Implementing logistics strategy	Looking to the future of SCM	Challenges for the future	Pricing and revenue management			Logistics/SC organisations
			Coordination in a SC			Logistics/SC control
			Information technology in a supply chain			

Table 1: Supply chain contents/topics covered in seven texts

	Theme	Key elements
1	Demand management	Demand forecasting/forecasting requirements/aggregate planning
2	Procurement & supply management	Purchasing/sourcing/strategic sourcing/sourcing decision/selection of supplier/contracts
3	Inventory management	Concept/control/ordering policy/modelling
4	Distribution/transportation	Warehousing/consolidation & facility location/material handling/storage and handling decisions
5	Managing material flows	Lean/JIT/MRP/agile
6	Synchronise supply chain	Collaborative planning/customer relationship/coordination/integrating supply chain/3PL/4PL
7	IT in supply chain	Information management/information system/order processing and information system/ERP systems
8	Supply chain design	Organising for effective supply chain/network design/network planning process/lead-time management
9	Global supply chain	International/global pipeline/global supply chain network
10	Performance and service	Metrics/performance measurement/customer service/customer value
11	Risk in supply chain	Risk management
12	Event logistics	Humanitarian logistics/disaster logistics
13	Supply chain sustainability	Reverse logistics/green logistics/corporate social responsibility
14	Security in supply chain	Concept/new rule-regulation for security
15	Quality management in supply chains	Logistics quality/best practices/

Table 2: Supply chain themes and their key elements

Classification of regions

We classified the reviewed papers into eight categories based on the geographical context in which the articles were published. These categories are, in alphabetical order, Africa, AusNZ (Australia and New Zealand), CITSH (China (including Hong Kong), India, Taiwan and Singapore), Europe (excluding UK), North America (US and Canada), Other Asia, South America and UK.

TREND AND PATTERN ANALYTICAL RESULTS

The distribution of articles published in the five selected journals is shown in Table 3. About 36% of the reviewed articles were published in IJPDLM, 26% in SCMJ, 16% in JBL, 14% in IJLM and 9% in JOM. Figure 1 shows that the overall number of articles published in these journals between 1995 and 2009 has almost doubled.

Journal	Year established	Issues/ year	Total Paper	Papers in LSCM
International Journal of Physical Distribution & Logistics Management (JPDLM)	1971	3-10	670	652
Journal of Business Logistics (JBL)	1978	2	300	285
Journal of Operations Management (JOM)	1980	2-6	619	172
International Journal of Logistics Management (IJLM)	1990	2	255	250
Supply Chain Management: An International Journal (SCMIJ)	1996	3-6	472	469
Total			2316	1828

Table 3: Number of articles by journal

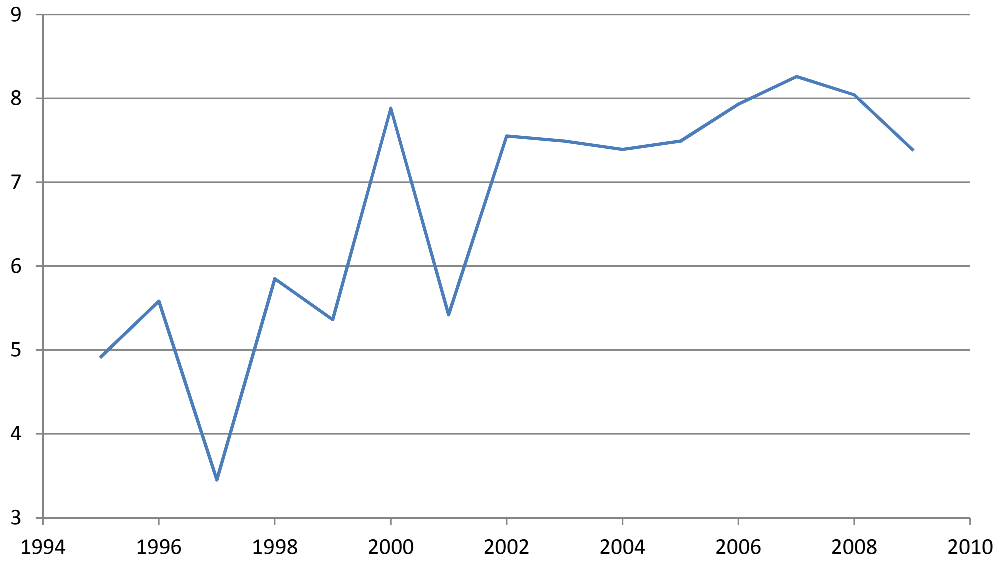


Figure 1: Number of articles published between 1995 and 2009

Theme-based analysis
The highest number of articles published in theme Synchronise supply chain (16.86%) and the lowest number of articles published in theme Security in supply chain (0.38%) (Table 4). The top five themes are synchronise supply chain, IT in supply chain, distribution and transportation, supply chain design, and procurement and supply management. These five themes together make up about 63% of the total publication. The distribution of publication in five themes between 1995 and 2009 is shown in Figure 2. Table 4 indicates that the relative increase in publication of the emerging supply chain themes is higher than the classical themes. For example, the number of publications in theme Risk in supply chain has been increased by 850% between 1995 and 2009, whereas, the publications in theme Managing material flow has been decreased by 73% over the same period.

Theme	1995-1999	2000-2004	2005-2009	% increased	Total	%
Security in SC	0	3	4	400	7	0.38
Global SC	14	41	24	71	79	4.32
SC Sustainability	15	26	31	107	72	3.94
Quality management	17	30	43	153	90	4.92
Synchronise SC	61	116	128	110	305	16.68
Risk in SC	4	29	38	850	71	3.88
IT in SC	48	111	90	88	249	13.62
Inventory Management	20	24	36	80	80	4.38
Managing material flow	22	20	6	-73	48	2.63
Distr & transport	59	60	93	58	212	11.60
Event Logistics	4	1	12	200	17	0.93
SC Design	76	55	73	-4	204	11.16
Procurement & supply	43	64	68	58	175	9.57
Demand management	8	26	27	238	61	3.34
Performance & service	10	17	18	80	45	2.46

Table 4: Number of articles by journal

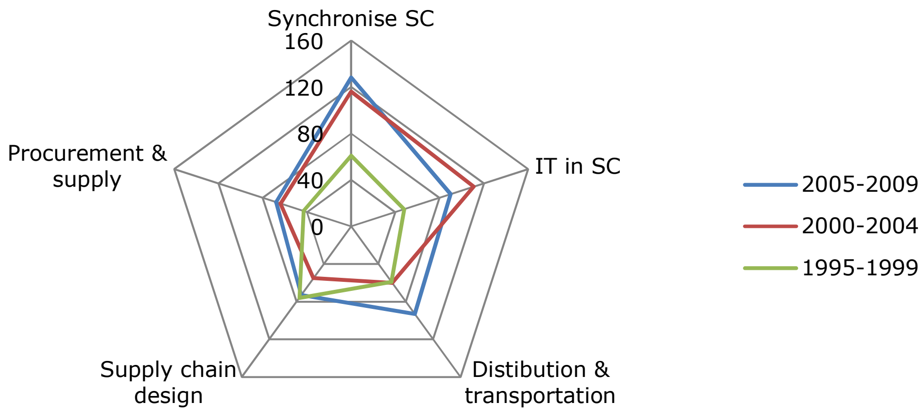


Figure 2: Distribution of publication top five themes between 1995 and 2009

Region-based analysis
The geographical region-based distribution of publication is given in Table 5. The highest number of articles was published in the context of North America followed by Europe and UK. The results show that over 51% of the reviewed articles were published in the context of North America, whereas only one article was published in the context of African countries. The results also show that the percentage increase in publication is relatively higher in the context of developing and emerging economies compared to developed economies (Table 6). For example, the number of articles published in CITSH countries increased by over 438% over the period of 1995 and 2009, whereas, the number of articles published in the context of North America increased by only about 31% during the same period. Tables 7 shows the distribution of publication based on the geographical region.

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Asia-others	0	4	1	3	4	1	2	1	4	3	9	3	5	4	6	50
AUSNZ	2	4	0	3	3	9	7	13	9	8	10	6	3	8	4	89
CITSH	4	1	1	3	4	14	5	2	10	4	8	24	7	15	16	118
Europe	10	14	3	22	16	29	15	26	34	27	20	30	41	29	22	338
N-America	69	57	38	49	53	65	55	77	62	71	73	53	75	76	70	943
S-America	1	0	2	0	1	0	0	2	1	0	0	2	0	4	4	17
UK	6	10	3	25	20	35	15	18	17	24	19	28	23	13	16	272

Table 5: Distribution of publication in different regions between 1995 and 2009

Region	1995-1999	2000-2004	2005-2009	% increased
Africa	0	0	1	100.0
Asia-others	12	11	27	125.0
AUSNZ	12	46	31	158.3
CITSH*	13	35	70	438.5
Europe	65	131	142	118.5
N-America	266	330	347	30.5
S-America	4	3	10	150.0
UK	64	109	99	54.7

Table 6: Relative increase of publication in different regions

Theme	Africa	Asia-other	AUSNZ	CITSH	Europe	N-America	S-America	UK
Security in SC	0	0	2	0	1	3	0	1
Global SC	0	2	6	2	5	33	2	14
SC Sustainability	0	3	3	3	7	41	0	8
Quality management	0	4	5	3	6	43	3	14
Synchronise SC	0	10	11	11	26	163	3	37
Risk in SC	0	4	4	2	5	33	1	12
IT in SC	0	1	12	9	20	139	0	36
Inventory Management	0	2	3	1	5	57	0	4
Managing material flow	0	2	5	1	1	24	1	8
Distr & transport	0	4	9	14	35	83	1	21
Event Logistics	1	0	2	0	1	7	0	6
SC Design	0	5	12	9	8	110	2	36
Procurement & supply	0	7	5	11	6	97	1	34
Demand management	0	1	2	3	7	21	1	12
Performance & service	0	3	4	0	4	25	2	3

Table 7: Supply chain themes and regions

CONCLUSIONS

Our main objective has been to (i) review articles in selected supply chain periodicals for their contribution to research in various supply chain themes, (ii) classify the literature based on a suitable classification scheme, leading to some useful insights into supply chain research and (iii) develop a framework for some future research directions. This paper provides a comprehensive assessment of 1828 articles in logistics & supply chain management, published in five supply chain periodicals between 1995 and 2009.

The analysis indicates that about 36% was published in IJPDLM, 26% in SCMJ, 16% in JBL, 14% in IJLM and 9% in JOM. We classified the reviewed articles into fifteen supply chain themes based on the content/topics of seven logistics and supply chain texts published between 1998 and 2010. The analysis shows that the highest number of articles was published in theme synchronise supply chain, whereas, the lowest number of articles was published in the security theme. The top five themes makes up about 63% of the total articles reviewed. The results also show that the percentage increase in publication is relatively higher in themes belonging to the emerging theme category compared to the classical theme category.

We classified the articles into eight categories based on the context (geographical region) in which the articles were published. The results of this study show that over 51% of the reviewed articles were published in the context of North America, whereas only one article was published in the context of African countries. The results also show that the percentage increase in publication is relatively higher in the context of developing and emerging economies compared to developed economies.

REFERENCES

1. Ballou, R. H. (2004), *Business Logistics/Supply Chain Management*, 5th edition, Prentice Hall, London.

2. Christopher, M. (2010), *Logistics and Supply Chain Management*, Financial Times, London.

3. Chopra, S. and Meindl, P. (2010), *Supply Chain Management: Strategy, Planning and Operations*, 4th edition, Pearson.

4. John J. Coyle, J.J, Bardi, E. J. and Langley Jr., C. J., (2003), *The Management of Business Logistics, A Supply Chain Perspective*, 7th Edition, South-Western-Thompson Learning, Minneapolis/St. Paul

5. Harrison, A. and van Hoek, R., (2008), *Logistics Management and Strategy*, 3rd edition, Prentice Hall, ISBN 0273712764.

6. Lambert, D. M., Stock, J. R. and Ellram, L. M., (1998), *Fundamentals of Logistics Management*, Irwin/McGraw-Hill, Boston.

7. Wisner, J. D., Leong, J. K., and Tan, K-C (2005), *Principles of Supply Chain Management: A Balanced Approach*, Thomson Business and Professional Publishing, Minneapolis/St. Paul.

TRUST AND THE END-TO-END SUPPLY CHAIN PERSPECTIVE

Christos Braziotis (corresponding author), Natalia Yannopoulou and James Tannock
Nottingham University Business School
Jubilee Campus, Wollaton Road
Nottingham, NG8 1BB, UK
E-mail: Christos.Braziotis@nottingham.ac.uk
Tel: +44 (0) 115 9514026

INTRODUCTION

Trust can affect Supply Chain (SC) relationships (Handfield and Bechtel, 2002), with mutual trust being a vital ingredient for a collaboration to succeed (Cohen and Russel, 2005). Trust plays a key role in repeated purchases and loyalty both in Business to Consumer (B2C) and Business to Business (B2B) relationships. Little attention, however, has been paid to the study of this central concept and how it affects the relationship between the main actors within businesses. There are very few empirical studies that focus principally on trust, while findings have often been contradictory (Sichtmann, 2007).

Through an extensive literature review, this paper attempts to build on past research from two different bodies of knowledge, namely from the disciplines of SC management and Marketing, in order to develop a more holistic understanding of the different views on trust in the end-to-end SC collaborative Network. In more detail, we first examine the importance of trust within the different levels of B2B, B2C and B2N and identify the different conditions of each such level that enhance trust in both the corporate and consumer level. We then focus on the importance of examining trust through a holistic view that takes into account the differences of each level. Subsequently, we present prominent empirical cases of well established companies, where crisis made the parties to rethink their trust towards their long trusted companies. By identifying the specific conditions of trust that have been affected in these case studies, we further build on the importance of these previously identified conditions, as necessary for the enhancement of corporate and consumer trust. To conclude, we present the theoretical and practical implications of our study for both SC management and marketing, along with areas for future interdisciplinary research.

LITERATURE REVIEW

2.1 The role of trust in the Supply Chain

Supply Chain (SC) collaboration and its vital ingredients are essential to sustain the competitive advantages for the whole network, and have consequently been the subject of considerable research (e.g. Ha *et al.*, 2011). The way of approaching trust theoretically and practically within the SC Network context follows a Business-to-Network (B2N) perspective. For instance, in the domain of SC management, long-term trust (i.e. the confidence that another party in the relationship will fulfil its promises and commitments without exploiting vulnerabilities) has been identified as a key ingredient in developing the mutual interdependence, commitment and *esprit de corps* that holds a collaborative SC Network together (Dyer, 2000).

Agarwal and Shankar (2003) suggested that trust is defined in terms of reliability, predictability, and fairness. Enhanced trust appears in the literature as an imperative to achieve improved SC performance and sustainable competitive advantage. Trust can have a positive impact on SC performance; creating significant economic value for SC members by increasing knowledge sharing and lowering transaction costs (e.g. Kwon and Suh, 2005). Nevertheless, although the judge of the SC performance is the customer, the effect of customer orientation on enterprise networks is not yet fully understood (Jeong and Hong, 2007).

Formal contracts may assist in ensuring both buyers and suppliers that trust is well-founded (Handfield and Bechtel, 2002). Therefore, considering Lockamy III and McCormack's (2004) five levels of SC maturity, namely Ad Hoc, Defined, Linked, Integrated, and the highly-partnered Extended level, one can argue that some level of trust should be evident in all five levels, which should increase as we move to more developed, hence more partnered, levels. Under partnership agreements companies may need to share information they previously considered proprietary (Cohen and Russel, 2005). Hence, trust has been associated with integrity, ensuring there is no abuse of sensitive information that could harm the partnered parties (Hines, 2004). It has been argued that successful partnerships, require high levels of trust to ensure their potential development and an eagerness among partners to assist (Chandra and Kumar, 2000; Simchi-Levi *et al*., 2008).

Long term relationships within businesses rely heavily on mutual dependence and the extent to which they trust one another. Within a Business-to-Business (B2B) context, trust relies on reputation and the perception of the relatedness of two organizations (Ganesan, 1994). Trust plays a key role both upstream and downstream the SC. To achieve customer trust and loyalty, a company has to be consistent and fair, while customer loyalty can be achieved through trust using CRM approaches. On the other side, trust and commitment between a company and its suppliers plays a key role in supplier development (Hines, 2004).

Trust is seen as a dynamic and continuous notion, while a much critical component of economic transaction. Within a Business-to-Consumer (B2C) context, trust presents a number of facets such as personality, cognitive, social, institutional, and emotional ones. Trust is therefore viewed as a multidimensional concept. As a result, most authors differentiate between cognitive and emotional trust. Cognitive trust is been defined as consumers' "rational expectation that a trustee will have the necessary competence, benevolence, and integrity to be relied upon," while emotional trust is defined as "the extent that a trustor feels secure and comfortable about relying on a trustee" (Komiak and Benbasat, 2004, p.28 and p.187). In other words, trust consists of an emotional base that is distinct from, but complementary to its cognitive base (Lewis and Weigert, 1985). This differentiation can be further developed by assigning trust beliefs on the cognitive aspect and trust attitude on the emotional aspect.

More recently, attention has been drawn to the influence of context with regards to especially behavioural outcomes. It has been argued that trust is required only in situations of uncertainty (Doney and Cannon, 1997) and high perceived risk, as at other times confidence or familiarity are sufficient for consumers to purchase a product or service (Elliott and Yannopoulou, 2007; Mitchell, 1999). It can be therefore argued that the main antecedents of trust are situations of high perceived risk, consumers' perceived quality information, perceived favourable reputation and prior experience (Zahedi and Song, 2008).

2.2 The importance of Trust in B2C and B2B relationships

Most of the research on trust in the SC focuses on collaboration upstream or downstream on a B2B level, or is generally attributed to what we could refer to as the SC Network level (the 'B2N'). Such research has typically taken place either within specific disciplines (e.g. Sahay, 2003), or longitudinally (e.g. Zahedi and Song, 2008). Following latest paradigm shifts in the way companies interact with each other in their SC, and the recent development of the Network paradigm, the need for an elaborated approach of trust on these distinctive levels has not been adequately identified. This paper concentrates on identifying the different conditions that enhance corporate and consumer trust both *along* and *within* the SC Network. This merits attention, particularly considering the upstream and downstream sides for a focal organisation, and whether trust should be treated on an institutional or individual basis. This way of approaching trust theoretically and practically creates a clear distinction between B2B and B2C levels of trust perception that requires further examination. For instance, while trust is hard to be built and sustained both within B2B and B2C levels, it does dissolve very quickly and easily (Siomkos and Kurzbard, 1994). Once there is a critical incident that brings it into question, it fails easily and only rarely does it get restored. The most opportune time to examine trust appears to be when consumers or businesses are facing a crisis situation, which makes them question their level of trust. Our paper aims to propose a more holistic study of this vital concept through critically reviewing the literature on trust, utilising published case studies and examining company crises, namely how they have been developed, addressed, resolved and the consequences generated, as can be seen next.

3. CONCEPTUAL FRAMEWORK

Trust should be approached and analysed within the different levels of a network. Indeed, authors have approached trust on domains that constitute parts of the SC Network. However, such approaches have been so far independent of considering the SC Network. This distinction of the B2N perspective into B2B and B2C levels does not constitute a tautology, as different elements of trust, and, indeed, different forms of trust become essential for effective relationships. Figure 1 illustrates the three different proposed levels of trust on which it can be examined.

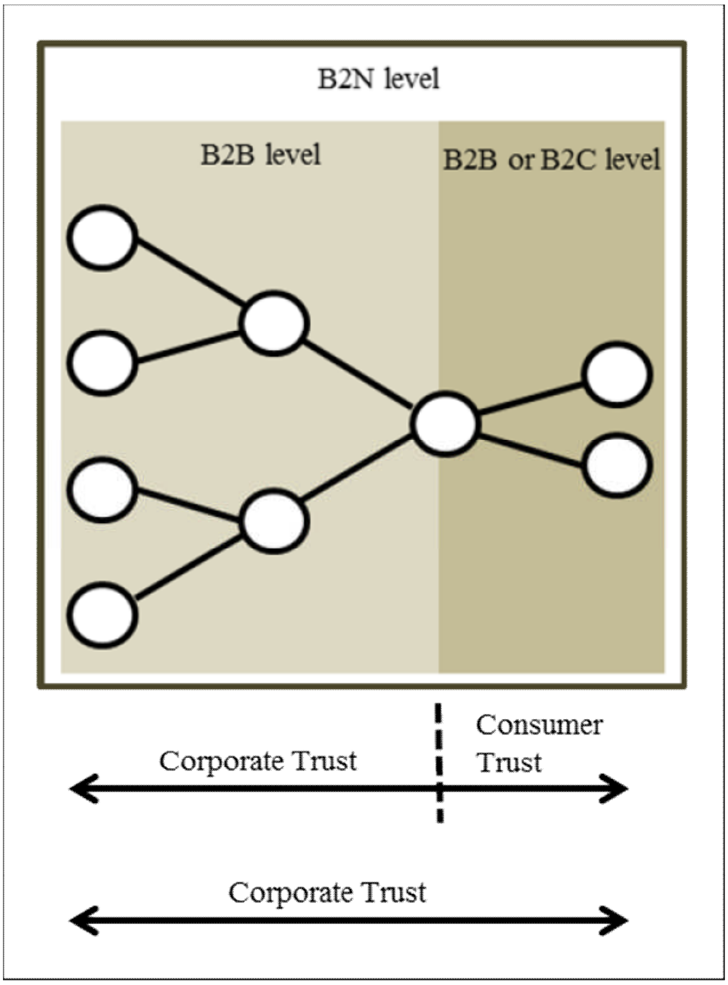


Figure 1: The Different levels of trust

Considering the whole network (B2N level), the perspective adopted is holistic, and subject to what we term as 'corporate trust'. The importance of institutional (as opposed to individual) trust that needs to be in place for companies and their suppliers to effectively collaborate has been stressed. Although this is not always the case, it is trust between institutions (i.e. companies) that needs to be established for the collaboration to bring out its full potential. Indeed, a rather significant amount of the trust-related literature has focused on this perspective (e.g. Kidd, 2003).

The upstream side of a company's SC (B2B level) is subject to corporate trust, creating specific implications as discussed above. This dyadic or multi-entity B2B type of trust takes place among institutions. Nevertheless, the downstream side of a company’s SC is the area that may be subject to either corporate (B2B), or non-corporate type of trust (B2C level), namely consumer trust.

Figure 1 also illustrates what we term ‘the trust conversion point’, i.e. a specific node in the SC where corporate trust may transform into consumer trust and vice versa. This transformation takes place at the node of the organisation responsible for marketing the final product to individual consumers (illustrated in figure 1 with the dotted line). In many cases, the examination ends within the B2B level, while in others it extends to the end consumer, including the B2C level.

Identifying the trust conversion point in the SC is important. As discussed in the literature review, different considerations become relevant on either side. More specifically, the main conditions for enhanced corporate trust are information sharing, integrity, eagerness to assist, and mutual interdependence and commitment. On the other hand, the main conditions for enhanced consumer trust are time/repeated purchases (prior experience), perceived risk, perceived quality information, and perceived favourable reputation. Drawing from practical case examples, we explore trust and its different conditions on the B2B and B2C level within the B2N level. It is of interest how the conditions and situations that put trust on test within one level (e.g. B2C) may affect trust on the other (e.g. B2B).

For instance, in 2006, Dell recalled 4.1m laptops, the largest recall of electronic products in history, due to battery failures (BBC, 2006). With defective laptops bursting into flames, consumer's trust in Dell was put at the test. Consumers' trust in Dell was heavily damaged, with blogs and Internet sites proliferating to add to the company's bad publicity. The conditions of consumer trust previously mentioned that were affected were, predominantly, perceived risk (safety risk involved) and favourable reputations (mass media coverage and negative consumer generated content).

In Dell's effort to handle the crisis, the company assigned the blame to Sony who manufactured the batteries, arguing that Sony had contaminated the battery cells in the manufacturing process. That way, the B2C level trust crisis passed the conversion point into the B2B level. Sony responded, initially, by counter-blaming Dell and its system configuration process, as the same batteries were also used in Sony's Vaio laptops with no problems. This refers to the corporate trust condition of mutual interdependence (in terms of long-term sourcing of the products for the specific designs). As a consequence Sony offered to financially help Dell in the recall of the laptops (Lynch, 2006).

In another case, recently Qantas' superjumbo Airbus A380 fleet had to be grounded due to an engine failure on a Rolls-Royce's Trent 900 gas turbine engine. Qantas assigned the blame to Rolls-Royce (RR) and determined that their A380s would not fly as long as the problem with the engines was unresolved. This incident affected the 20 A380s in service fitted with the Trent 900 engines (The Guardian, 2010). As a result, RR inspected the entire Trent 900-powered fleet, paying out the affected customers (Qantas, Singapore Airlines and Lufthansa) for most of the service and support costs and settlements, around £56m (Laig, 2011). Nevertheless, although Rolls-Royce identified and rectified the cause of the engine failure, they did not officially confirm the faulty component's nature (making reference only to a "specific component"), or indeed whether the problem could be assigned to a specific supplier (Gilbert, 2010). This crisis refers to the B2B level, as the product affected was an engine sold to corporate customers, with the relevant conditions affected being mutual interdependence and commitment. The crisis, however, was also experienced by Qantas passengers, the customers for the travel service. This also exhibits the passage of trust over the conversion point from the B2B level into the B2C one. The consumer trust condition affected was the perceived risk.

4. DISCUSSION AND CONCLUSIONS

The previous section suggests that trust within the SC is a multi-facet concept made out of different types of trust depending on the varying conditions within the levels under investigations. We were therefore able to identify the conditions that enhance corporate and consumer trust, along with the conversion point at which trust changes in nature between these two types. The examination of such an important concept should not be confined within the boundaries a specific research area. Currently, from a SC perspective, the end-to-end approaches (B2N) fails to identify the different types of trust that need to be handled. There are different types of trust generated along the SC, and attention has to be drawn to consumers as their role is vital to the preservation or not of trust throughout the whole network. Even within B2B or B2N contexts, the end consumer needs to always be taken into consideration. As illustrated in the case studies above consumer trust during and after the crisis towards the OEM that determines its market recovery along with the network's long term survival.

The value of this paper lies in establishing a cross-disciplinary account and understanding of the role of trust, by combining perspectives from SCM and Marketing. The end-to-end approach followed (B2C, B2B and B2N) contributes to the discourse on trust and SC collaboration, and offers practitioners practical guidelines for trust development and long term preservation. Future research could focus on further examining the different nature of trust along the SC, focusing on the role of end consumer in recovery plans. This could be especially studied under a multi-disciplinary perspective.

REFERENCES:

Agarwal, A. and Shankar, R. (2003) "On-line trust building in e-enabled supply chain", *Supply Chain Management: An International Journal*, Vol. 8 (4), pp. 324-334.

BBC (2006) "Dell recalls 4m laptop batteries", in World Wide Web, URL: http://news.bbc.co.uk/1/hi/4793143.stm [Accessed 18 April, 2010].

Chandra, C. and Kumar, S. (2000) "Supply chain management in theory and practice: a passing fad or a fundamental change?", *Industrial Management & Data Systems*, Vol. 100 (3), pp. 100-113.

Cohen, S. and Russel, J. (2005) Strategic Supply Chain Management: The Five Disciplines for Top Performance. Mc-Graw-Hill, New York.

Doney, P.M. and Cannon, J.P. (1997), "An examination of the nature of trust in buyer-seller relationships", *Journal of Marketing*, Vol. 61, pp. 35-51.

Dyer, H.J. (2000), *Collaborative Advantage: Winning through Extended Enterprise Supplier Networks*, Oxford University Press, New York.

Elliott, R. and Yannopoulou, N. (2007), "The Nature of Trust in Brands - A Psycho-Social Model", *European Journal of Marketing*, Vol.41(9/10), pp.988-998.

Ganesan, S. (1994), "Determinants of long-term orientation in buyer-seller relationships", Journal *of Marketing,* Vol.58 (2), pp.1-21.

Gilbert, H. (2010) "Rolls-Royce confirms faulty part caused Qantas flight explosion". World Wide Web, URL: http://www.supplymanagement.com/news/2010/rolls-royce-confirms- faulty-part-caused-qantas-flight-explosion/ [Accessed 25 April, 2011].

Ha, B., Park, Y. and Cho. S. (2011) "Suppliers' affective trust and trust in competency in buyers: its effect on collaboration and logistics efficiency", *International Journal of Operations & Production Management*, Vol. 31 (1), pp. 56-77.

Handfield, R.B. and Bechtel, C. (2002) "The role of trust and relationship structure in improving supply chain responsiveness", Industrial Marketing Management, Vol. 31 (4), pp. 367-382.

Hines, T. (2004) *Supply Chain Strategies: Customer Driven and Customer Focused*. Elsevier, Oxford.

Jeong, J.S. and Hong, P. (2007) "Customer orientation and performance outcomes in supply chain management", *Journal of Enterprise Information Management*, Vol. 20 (5), pp.578-594.

Kidd, J. (2003) "Learning and trust in supply chain management", *Management Decision*, Vol. 41 (7), pp.603-612.

Komiak, S. and Benbasat, I. (2004) "Understanding customer trust in agent-mediated electronic commerce, Web-mediated electronic commerce, and traditional commerce", *Information Technology and Management,* Vol.5 (1–2), pp.181–207.

Kwon, I.G. and Suh, T. (2005) "Trust, commitment and relationships in supply chain management: a path analysis", *Supply Chain Management: An International Journal*, Vol. 10 (1), pp. 26-33.

Laig, I. (2011) "Qantas superjumbo engine explosion costs Rolls-Royce £56m". NEBUSINESS, World Wide Web, URL: http://www.nebusiness.co.uk/business-news/latest-business-news/2011/02/11/qantas-superjumbo-engine-explosion-costs-rolls-royce-56m-51140-28151848/ [Accessed 24 April, 2011].

Lewis, J.D. and Weigert, A. (1985) "Trust as a Social Reality", *Social Forces*, Vol. 63, pp.967-985.

Lynch, M. (2006) "Michael Dell blames Sony for fire-risk batteries". Computer Active, World Wide Web, URL: http://www.computeractive.co.uk/pcw/news/1925117/michael - dell- blames-sony-risk-batteries [Accessed 20 April 2010].

Lockamy III, A. and McCormack, K. (2004), "The development of a supply chain management process maturity model using the concepts of business process orientation", *Supply Chain Management: an International Journal*, Vol. 9 (4), pp. 272-278.

Mitchell, V. W., (1999) "Consumer Perceived Risk: Conceptualisations and models", *European Journal of Marketing*, Vol. 33 (1/2), pp. 163-95.

Sichtmann, C. (2007) "An analysis of antecedents and consequences of trust in a corporate brand", *European Journal of Marketing*, Vol. 41 (9/10), pp. 999-1015.

Simchi-Levi, D., Kaminsky, P. and Simchi-Levi, E. (2008) *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Mc-Graw-Hill Irwin, 3rd edition, New York.

Siomkos, G.J. and Kurzbard, G. (1994) "The Hidden Crisis in Product-hard Crisis Management", European Journals of Marketing, Vol. 28 (2), pp. 30-41.

The Guardian (2010) "Rolls-Royce identifies cause of Qantas A380 explosion". World Wide Web, URL: http://www.guardian.co.uk/business/2010/nov/12/rolls-royce-traces-a380-fault [Accessed 22 April, 2011].

Zahedi F. and Song, I. (2008) "Dynamics of Trust Revision: Using Health Infomediaries", *Journal of Management Information Systems*, Vol. 24 (4), pp. 225–248.

SECTION 2 – SUPPLY CHAIN NETWORKS, COLLABORATION AND CULTURE

READINESS FOR SUPPLY CHAIN COLLABORATION & SUPPLIER INTEGRATION – FINDINGS FROM THE CHINESE AUTOMOTIVE INDUSTRY

Joachim Schadel – European Business School
Martin Lockström – China Europe International Business School
Roger Moser – European Business School & Indian Institute of Management Bangalore
Norma Harrison – China Europe International Business School

1. INTRODUCTION

The efforts among automotive companies in China to find suitable domestic suppliers have to be seen as a response to local content requirements as promulgated by the Chinese central government but also as part of the global sourcing strategy among the producers. Therefore, automotive companies both original equipment manufacturers (OEMs) and their Western suppliers are currently trying to integrate more domestic suppliers in their supply chains in China (Holweg et al., 2005). The automotive industry is suitable for further research of complex buyer-supplier interactions because it can also be considered a networked industry implying that it is virtually impossible for any firm alone to possess all the technical expertise and capabilities needed to develop and produce a complex product (Holweg and Pil, 2007, Binder et al., 2007).

The goal of this paper is to contribute to theory building of supplier integration in the specific context of the Chinese automotive industry by analyzing empirical data gathered from a series of exemplary cases. The paper aims at answering the following research questions: 1. How is supplier integration characterized in the Chinese automotive industry? 2. What are antecedents to supplier integration in the Chinese automotive industry?

2. LITERATURE REVIEW

The existing body of supply chain management research is replete with empirical studies on supplier selection, supplier relationship management, supply chain integration and management (Bowersox, 1999, Frohlich and Westbrook, 2001, Malhotra et al., 2008). Consequently, a new paradigm evolved among numerous scholars that positions the purchasing function in a company into a more strategic setting emphasizing the importance of supplier management for the generation of competitive advantage (Watts et al., 1995, Narasimhan and Das, 2001, Möller and Törrönnen, 2003). The complexity of tasks in the automotive industry strongly suggests the implementation of collaborative concepts and approaches in such a networked industry (Tang and Qian, 2007). As supported by a vast amount of evidence collaborative approaches result in improved product quality, shorter lead times and a higher responsiveness of the supply chain, lower cost and increased customer satisfaction (Humphreys et al., 2007, Bennett and O'Kane, 2006).

Hereby, it has been found that product modularization reduces the complexity within the supply chain and plays a decisive role in particular in the automotive sector to facilitate supply chain linkages (Doran, 2003). It has been found as well that order-driven supply chains strengthen the need for stronger synchronization of production planning processes (Holweg and Pil, 2007). Besides collaborative production planning (Bennett and O'Kane, 2006) collaborative product development (Takeishi, 2001) can be identified as a main form of collaborative relationships.

Supplier integration, supply chain integration, and collaborative relationships

This paper adheres to several existing theories relating to *supply chain integration* (SCI), of which *supplier integration* (SI) is defined as a subset belonging to the upstream part of the supply chain. SCI is defined as series of activities intended to organize the material, information and cash flow across traditional functions within companies and across

companies (Bowersox, 1999). This approach can be broken down into strategic, operational, flexible and financial aspects (Malhotra et al., 2008).
In congruency and adaption to several concepts of collaborative buyer-supplier relationships in literature (Kraljic, 1983, Bensaou and Venkatraman, 1995), this term is defined in the context of this paper as relationships that are characterized by trust, interaction, mutual responsibility, mutual risks and benefits, autonomous problem solving capabilities of the involved partners, and a pro-active approach towards new challenges.

3. METHODOLOGY

Research Design

Although there is some research on purchasing and supply management in China (Pyke et al., 2000, Cai and Yang, 1999), there is an apparent gap in the existing literature on these topics in the Chinese automotive industry. As the validity and reliability of frameworks developed based on empirical studies conducted in the West cannot be taken for granted (Hoskisson et al., 2000), combined with the overall lack of knowledge in this specific research context, an exploratory approach without prior assumptions or propositions was chosen. Therefore, an exploratory and inductive approach based on grounded theory was chosen for this study (Glaser and Strauss, 2006).

Sampling

As the purpose of the research was to capture the circumstances and conditions of an everyday and commonplace situation, a so called *representative case* implying a holistic, multiple-case study approach was designed (Yin, 2003). The major rationale was to gain insight in the experiences of the average sourcing professional directly involved in the procurement of supplies in the Chinese automotive industry. As the purpose of the study was theory building, a theoretical sampling approach was deployed.

Data Collection

Data was collected through semi-structured interviews in order to accomplish a certain degree of comparability while ensuring an unobstructed flow of narrations (Bryman, 2004). The informants involved in the study were purchasing, quality and supply chain managers from automotive companies. Two investigators were deployed for the interviews in order to "enhance the creative potential of the study" and to facilitate "convergent perceptions" (Eisenhardt, 1989). Each interview was conducted face-to-face, voice recorded (unless disapproved by the interviewee) and finally transcribed. Interviews were carried out in a sequential manner until a state of information saturation was accomplished (Glaser and Strauss, 2006), resulting in a total number of 30 interviews with automotive companies.
Instances of rivaling propositions were also investigated (Marshall and Rossman, 1995). Any such negative instance or rivaling proposition was questioned together with supervisors or managers in subsequent interviews. This was done in accordance with the consistency principle (Rubin et al., 1995) that requires researchers to further investigate responses that appear inconsistent.

4. ANALYSIS AND RESULTS

Upon completion of each interview, the voice recordings were transcribed into a text format, resulting in 650 pages of textual material. In order to assure validity, four techniques as proposed by Maxwell (2006) were deployed. In the open coding step, the interview transcripts were analyzed line by line breaking the data down into discrete parts (i.e. words, sentences and paragraphs) yielding 1,253 initial codes. Next, in the axial coding step, data were put back together in new ways by making connections between categories (Corbin and Strauss, 1990).

Supplier Integration

The first construct that emerged out of the interview analysis was supplier integration (SI). The overall concept turned out to be similar with the common definitions in literature where buyers (i.e. OEMs/first-tier suppliers) and their suppliers try to improve

supply chain performance through joint activities in regard to information exchange, data transparency increase, production planning etc. (Malhotra, 2008; Zhao et al. 2007).
Joint production planning. This is the first dimension of the SI construct and involves the planning and execution of supply-chain-wide master plans (Pibernik and Sucky, 2006). Moreover, it contains tactical and short-term activities needed in order to ensure timely delivery of direct materials for production such as the development and sharing of master production plans, or inventory levels and feedback on potential delivery delays or similar disruptions. These activities required the existence and transparency of accurate and relevant planning information within companies and synchronized exchange between supply chain echelons. It turned out in the interviews that this activity was mainly carried out manually or semi-automatically.
Furthermore, the level of integration of the material flow was investigated. It turned out that deliveries took place in some cases in daily, but mostly in weekly or monthly lot sizes. It also turned out that advanced logistics and supply chain concepts, such as just-in-time (JIT) or vendor managed inventories (VMI) were possible in only a few cases. Continuous improvement processes, however, were implemented among half of the domestic suppliers.
Joint product development. This dimension of the supplier integration category proved to involve collaborative activities between the OEM and its key supplier(s) that were needed to bring new car models to the market at the lowest cost and as fast as possible (Binder et al., 2007). Early supplier involvement (ESI) and value analysis (VA) were major activities of this category. The actual joint product development activities proved to take place at three distinct levels, namely (1) process-related product modifications which occurred most often and refer to changes of the technical specifications due to different production processes and techniques without changing the overall product characteristics and functional requirements, (2) product-related changes in order to better adapt to the needs of local customers, e.g. elongated car bodies with more back seat leg space, and (3) new product development capability.
Communication Technologies and Patterns. This dimension of supplier integration involved the means through which communication between buyers and suppliers take place on a daily basis. The automotive companies in the West rely on a high level of electronic information exchange through the use of online supplier portals, e-sourcing tools and EDI for the information exchange between buyers and suppliers. In the Chinese automotive industry, this information exchange turned out to take place at a more basic level with frequent use of telephone, fax and e-mail.
Strategic Planning. This dimension of supplier integration involved all kinds of long-term planning such as capacity, demand or product planning as well as sharing of new ideas and alignment of long objectives. Based on the analysis, the decisive factor is the maturity of the buyer-supplier relationship. Automotive companies that have done business with domestic suppliers for a long-term period also tended to involve them more often in long-term planning. However, it was evident that the stronger supply chain partner (i.e. the foreign buyer) usually dictated the activities.
Organizational Integration. This dimension involved all kinds of joint investments (financial and non-financial) in joint infrastructure (physical and non-physical). According to our results, major activities included process development and continuous improvement in order to optimize the organizational interface between the buyer and supplier. Another identified key activity was supplier development programs where cross-functional teams consisting of buyers, logistics experts, quality engineers and production managers were sent to a supplier’s facilities to improve production processes and train staff and management. It also turned out that most buyers have some sort of contingency plans in place as part of the contract with a supplier in case unforeseen events or problems would occur.

Collaborative Supplier Capabilities
After examining the concept of supplier integration in the Chinese automotive industry, interviewees were asked to elaborate on factors that facilitate and drive supplier integration in the Chinese automotive industry.

Process management capability. The first dimension of collaborative supplier capabilities that emerged from our data was process management capability. It appeared to be one of the most important ones as most respondents claimed that it enables producers to effectively achieve adequate quality, delivery, productivity, and at the end also cost levels. According to the respondents, this capability has to be shown in basically any activity of the supply, development, production, and delivery process. Consequently, reliable and stable processes seem to be a prerequisite for supplier integration in the automotive industry.

Performance management capability. Another common SI driver highlighted in twelve cases was the frequent difficulty of managing production and delivery performance (Kaplan and Norton, 1992). Despite a high willingness to learn (indicated in 8 cases) and to invest in improvement activities the experience was that a lack of targets, performance indicators and action plans, lead to instable results and gradually drifts away from pre-defined levels. Other stated reasons for this phenomenon were high staff turnover rates, a lack of organizational learning and broken information feedback loops within the Chinese companies.

Communication/Autonomous problem solving capability. One of the most frequently occurring challenges concerning supplier integration in the Chinese automotive industry (22/30 cases) was the difficulty in effectively communicating with suppliers. This was the case especially concerning problem identification where most suppliers were described to be very reactive. Twenty-one of the 30 cases indicated this capability to be of essential importance further stressing this inhibiting factor for supplier integration. In general, this problem led to situations where buyers had to spend considerable resources on supplier monitoring and inspection on a continuous basis in order to discover potential problems at an early stage.

Planning capability. Partly interlinked with the process management capability, the planning capability within a company and across companies was named as a prerequisite to manage processes across the supply chain in a reliable and stable manner (indicated 15/30 cases). Many of the suppliers were said to lack experience in collaborative production and development activities.

Evidently, accurate and relevant planning information regarding orders, inventories, capacities etc. were often reported to be missing. In most cases, missing information systems or the lack of a systematic approach were suggested as possible reasons for this situation.

Engineering/Innovation capability. This capability was emphasized as one of the key drivers for strategic partnerships with suppliers in 21 of the cases. Despite a high degree of openness and willingness to learn and develop the level of innovations stemming from domestic suppliers still proved to be very low. The research results did not reveal a single case where genuine product development took place. The few instances where joint R&D activities happened turned out to be limited to product modifications primarily on the initiative and guidance of the buyer. As most of the interviewees indicated the ability to develop a component on the basis of functional requirements as a prerequisite for supplier integration the level of difficulty is apparent.

The above discussion leads to the following proposition:

P1. The aggregate level of collaborative supplier capabilities has a positive impact on supplier integration.

Supplier Collaboration Readiness

Following the discussion about the importance and impact from collaborative supplier capabilities on supplier integration, the next question is indeed how such supplier capabilities can be developed and maintained.

Quality mindset/Customer orientation. In instances where successful buyer-supplier interaction had taken place it was evident that a quality mindset permeated the supplier organization from top to bottom. Examples of such values and beliefs were a perceived importance of quality, zero tolerance for defects, paying attention to details in operations, continuous improvement and an acknowledged importance of the customer.

Top management support. According to the data it seems difficult to build and nurture the same kind of thinking throughout the organization unless supported by senior management. Collectively, these values and beliefs can be summarized as top management mindset.

Strategic alignment. The results also showed that those suppliers that were involved in successful collaborative projects with their customers were also highly motivated. This motivation was manifested in several ways. First, highly motivated suppliers turned out to have a high willingness to follow – that is, they seemed to have realized the benefits of making necessary changes and adaptations to their strategy, processes and organization in order to make their customer relationships work.

Willingness to learn/improve. In parallel with the strategic orientation among successful collaborative supplier-buyer relationships those suppliers also showed a great interest in learning and improving. The willingness to learn and improve also seemed to be coupled with the supplier mindset in a sense that suppliers must have acknowledged the need for improving performance in order to invest time and money in training and improvement activities.

Long-term orientation. Product development in the automotive industry is a costly and lengthy process. Thus, it is no surprise that well integrated suppliers had adopted a long-term view where expenses today were perceived as investments in future benefits. This factor proved to be one of the more common problems when dealing with domestic suppliers in China. They often tend to prioritize short-term profit over long-term objectives such as overseas expansion, technology leadership, excellent customer service and quality excellence.

Trust. In buyer-supplier relations characterized by a high degree of supplier integration the data shows that a high level of trust from the supplier's side was prevalent. In contrast, in those instances where the level of trust was low suppliers were not willing to take the financial risk implied from engaging in new automotive development projects, investments in new equipment/machinery and staff training activities.

The elements identified above might be aggregated to a conceptual construct called *supplier collaboration readiness*. Without top management support, willingness to learn and improve, the right strategic orientation and a trust in a non-opportunistic relationship it is not possible to develop and maintain the required supplier capabilities. The second proposition is therefore defined as follows:

P2. Supplier collaboration readiness has a positive impact on the level of collaborative supplier capabilities.

Buyer Leadership

Another aspect that emerged out of the coding of the transcribed interviews was the role of leadership. Most recent leadership research has primarily focused on "influencing a group of people to achieve a common goal" within one's own organization (Northouse, 1997) by virtue of formal power and authority (French and Raven, 1959). The data analysis of this study indicates that leadership might in fact also span across firm boundaries.

The empirical data also suggests that there exists a set of behaviors related to leadership. The relevant aspect in our study proved to be the leadership behaviors towards the supplier organizations. Almost all decision makers from buying organizations involved in collaborative supplier activities tended to apply a sort of situational leadership style (Hersey and Blanchard, 1969) depending on the relationship atmosphere and urgency of the matter.

It turned out that leaders who allegedly had managed to facilitate a high degree of collaborative readiness among the suppliers had taken a systematic approach. They did not only focus their efforts on one function but rather targeted the senior management among their suppliers and actively worked at a very personal level to convince these managers to adopt values, beliefs, make strategic adaptations, investments in new machinery/equipment etc. in line with the strategic orientation of their own company.

The third proposition is defined as follows:

P3. Buyer leadership effectiveness has a positive impact on supplier readiness.

Continuous Supplier Development
Another construct that emerged during the axial coding of the interview data turned out to be *continuous supplier development.* Conceptually, the construct involves activities from organizing relevant training for the supplier at various levels (e.g. FMEA, APQP, TQM etc.) to consulting activities at the supplier's facilities.
The fact that supplier development is a common and acknowledged practice in the automotive industry is no news. However, the results indicate a more idiosyncratic side of the concept. In fact, it seems that supplier development activities must take place on a *continuous basis*. Most respondents agreed that it was seldom enough to invest once into some supplier development activities for a specific supplier. In many of the cases supplier performance started to become volatile and drift away from target levels as soon as supplier development activities were stopped. The fourth proposition thus is as follows:

P4. The level of continuous supplier development has a positive impact on the level of collaborative supplier capabilities.

Internal Constraints
The data coding also revealed that the challenges concerning supplier integration in the Chinese automotive industry are not only related to the domestic suppliers. In fact, many cases indicated that some of the biggest bottlenecks were related to internal issues. One of the most prevalent internal challenges was identified as unrealistic headquarters expectations. TThe discrepancy between expectations was also manifested through insufficient provision of resources for local operations in terms of staffing and financing. Moreover, a common lack of on-site testing facilities resulted in lengthy sample inspections cycles which causes frustrations among the domestic suppliers and hinders the buying firms to position themselves as "valued customers". Based on the above discussion, the fifth proposition is defined as follows:

P5. The level of internal constraints is negatively moderating the relationship between buyer leadership effectiveness and supplier readiness.

Cultural Distance
This study does not deliberately investigate the impact from specific cultural characteristics such as power distance, masculinity, uncertainty avoidance, individualism etc. (e.g. Hofstede (1980); Javidan et al. (2006). Regardless of any conceptual culture frameworks elaborated in the literature, cultural distance is almost always manifested in differences in interpersonal communication. Also the ways business relationships are built in China vary different from the West. Clearly, the coding revealed culture to be an influencing factor. It turned out that cultural differences and a lack of cultural understanding in many cases hinder supply managers from effectively doing their job because it makes actions and counter-actions of the supplier more difficult to anticipate. Therefore, the sixth proposition is stated as follows:

P6. The level of cultural distance is negatively moderating the relationship between buyer leadership effectiveness and supplier readiness.

Collectively, the six propositions form a causal framework identifying important antecedents to supplier integration in the Chinese automotive industry. An overview of the conceptual framework is depicted in Figure 1.

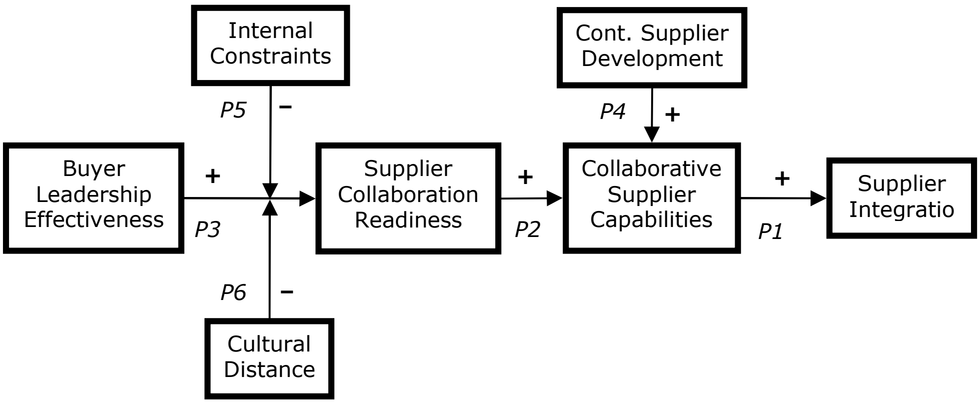


Figure 1: Conceptual framework of antecedents to supplier integration

5. Conclusions

The developed conceptual framework is based on an extensive analysis of recent and current supplier integration practices in the Chinese automotive industry. The study results contribute specifically by adding a specific perspective on supplier integration analyzing the antecedents of supplier integration in the Chinese automotive industry. Elements such as buyer leadership effectiveness might not be as relevant in a Western context but seem to be of importance in this specific context. The data analysis has revealed that there seldom exist concepts such as "one face to the customer or supplier" as each sourcing or product development project is executed by cross-functional teams from both sides with representatives from purchasing, production, logistics, product development etc. Furthermore, a so called 'leader' in this context does not seem to be limited to formal leaders; the data analysis in fact suggests that leadership seemed to exist at all hierarchical levels and all functions involved in the collaborative activities from the buyer's side.

It has also become clear from the data analysis that the local purchasing department in China serves as an interface and important linkage between the local suppliers and the internal customers located outside of China emphasizing the limiting aspects of internal constraints and cultural distance.

Finally, the results contribute to a better understanding which elements might be necessary in a Chinese context to achieve a satisfactory level of supplier integration.

REFERENCES

BENNETT, D. & O'KANE, J. 2006. Achieving business excellence through synchronous supply in the automotive sector. *Benchmarking: International Journal,* 13**,** 12-22.

BENSAOU, M. & VENKATRAMAN, N. 1995. Configurations of interorganizational relationships: A comparison between U.S. and Japanese automakers. *Management Science,* 41**,** 1471–14.

BINDER, M., GUST, P. & CLEGG, B. 2007. The Importance of collaborative frontloading in automotive supply networks. *Journal of Manufacturing Technology Management,* 19.

BOWERSOX, D. J., CLOSS, D.J., STANK, T.P. 1999. *21st Century Logistics: Making Supply Chain Integration a Reality,* Oak Brook, IL., Council of Logistics Management.

BRYMAN, A. 2004. Qualitative research on leadership: A critical but appreciative review. *The Leadership Quarterly,* 15 (2004)**,** 729–769.

CAI, S. & YANG, Z. 1999. Development of Cooperative Norms in the Buyer-Supplier Relationship: The Chinese Experience. *Journal of Supply Chain Management,* Jan 2008; 44**,** 55-70.

CORBIN, J. & STRAUSS, A. 1990. Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology,* 13**,** 3-21.

DORAN, D. 2003. Supply chain implications of modularization. *International Journal of Operations & Production Management,* 2003; 23, 3/4; ABI/INFORM Global**,** 316-326.

EISENHARDT, K. M. 1989. Building Theories from Case Study Research. *Academy of Management Review,* Vol. 14, No. 4**,** 532-550.

FRENCH, J. & RAVEN, B. H. 1959. The bases of social power. *In:* CARTWRIGHT, D. (ed.) *Studies of Social Power.* Ann Arbor, MI: Institute for Social Research.

FROHLICH, M. T. & WESTBROOK, R. 2001. Arcs of integration: an international study of supply chain strategies. *Journal of Operations Management,* 19 (2)**,** 185–200.
GLASER, B. G. & STRAUSS, A. L. 2006. *The discovery of grounded theory: strategies for qualitative research,* New Brunswick, Transaction.
HERSEY, P. & BLANCHARD, K. 1969. Life-cycle theory of leadership. *Training and Development Journal,* 2 (May)**,** 6-34.
HOFSTEDE, G. 1980. *Culture's Consequences: International Differences in Work-Related Values,* Beverly Hills, CS, Sage Publications.
HOLWEG, M., LUO, J. & OLIVER, N. 2005. The past, present and future of China's automotive industry: a value chain perspective. *International Journal Technological Learning, Innovation and Development***,** 1-43.
HOLWEG, M. & PIL, F. K. 2007. Theoretical perspectives on the coordination of supply chains. *Computers in Human Behavior,* 23**,** 424–462.
HOSKISSON, R. E., EDEN, L., LAU, C. M. & WRIGHT, M. 2000. Strategy in Emergin Economies. *Academy of Management Journal,* Vol. 43, No. 3**,** 249-267.
HUMPHREYS, HUANG, G., CADDENA, T. & MCIVOR, R. 2007. Integrating design metrics within the early supplier selection process. *Journal of Purchasing and Supply Management,* 13 (2007)**,** 42–52.
JAVIDAN, M., DORFMAN, P. W., DE LUQUE, M. S. & HOUSE, R. J. 2006. In the eye of the beholder: Cross cultural lessons in leadership from project GLOBE. *Academy of Management Perspectives,* 20**,** 67-90.
KAPLAN, R. S. & NORTON, D. P. 1992. The Balanced Scorecard - Measures That Drive Performance. *Harvard Business Review,* 70**,** 71-79.
KRALJIC, P. 1983. Purchasing Must Become Supply Management. *Harvard Business Review,* 61**,** 109-117.
MALHOTRA, M. J., SAEED, K. A. & JAYARAM, J. 2008. Impact of alliance readiness on supply chain integratyion and form's operational performance. China Europe International Business School.
MARSHALL, C. & ROSSMAN, G. B. 1995. *Designing Qualitative Research,* Newnan, GA, U.S.A., Hippo Books.
MAXWELL, J. A. 2006. *Qualitative research design: An interactive approach,* Thousand Oaks, CA, Sage.
MÖLLER, K. E. K. & TÖRRÖNNEN, P. 2003. Business suppliers' value creation potential A capability-based analysis. *Industrial Marketing Management,* 32**,** 109–118.
NARASIMHAN, R. & DAS, A. 2001. The impact of purchasing integration and practices on manufacturing performance. *Journal of Operations Management,* 19**,** 593-609.
NORTHOUSE, P. 1997. *Leadership: Theory and Practice* London, Sage Publications.
PIBERNIK, R. & SUCKY, E. 2006. Centralised and decentralised supply chain planning. *International Journal of Integrated Supply Management,* Vol. 2, Nos. 1/2**,** 6-27.
PYKE, D., ROBB, D. & FARLEY, J. 2000. Manufacturing and Supply Chain Management in China: A Survey of State-, Collective-, and Privatelyowned Enterprises. *European Management Journal,* 18**,** 577–589.
RUBIN, H. J., RUBIN, I. & RUBIN, I. S. 1995. *Qualitative Interviewing: The Art of Hearing Data,* Russellville, AR, U.S.A., Vintage Books.
TAKEISHI, A. 2001. Bringing inter and intra firm boundaries: Management of supplier involvement in automobile product development. *Strategic Management Journal,* 22**,** 403-433.
TANG, D. & QIAN, X. 2007. Product lifecycle management for automotive development focusing on supplier integration. *Computers in Industry,* 59**,** 288–295.
WATTS, C. A., KIM, K. Y. & HAHN, C. K. 1995. Linking Purchasing to Corporate Competitive Strategy. *Journal of Supply Chain Management* 31(2)**,** 2-8.
YIN, R. K. 2003. *Case Study Research: Design and Methods,* Thousand Oaks, CA, Sage.

CO-OPETITIVE STRATEGIES IN SUPPLY CHAINS: FROM INFORMATION SYSTEM TO SOCIAL TIES

Virginie Hiesse
MRM-ERFI, Université Montpellier I, France
v.yes@wanadoo.fr

Hervé Fenneteau
MRM-CR2M, Université Montpellier I, France
herve.fenneteau@univ-montp1.fr

Gilles Paché
CRET-LOG, Aix-Marseille Université, France
gilles.pache@univmed.fr

ABSTRACT
This paper examines the impact of information systems on the spreading of collaborative logistical practices between rival companies in the same market. Numerous pooling experiments are conducted, in France particularly, that lead manufacturers to voluntarily share resources and logistical activities. A large number of academic works highlight the main aspects of logistical collaborative strategies though emphasis is on the part played by information systems. It is at least as important to understand how competing firms will collaborate to implement a shared information system, even if it means disseminating strategic and confidential data outside their premises. The paper suggests widening the analysis by pointing out that the success of co-opetitive strategies in supply chain networks also implies the weaving of powerful social ties between decision makers.

INTRODUCTION

Since the mid 2000s, supply chains have become supply chain networks governed by activity and resource pooling behaviors between firms that can end up as competitors in the same market (Zhang, 2006). This development refers to two essential issues: logistical integration (Paulraj & Chen, 2007), and co-opetition relationships (Kotzab & Teller, 2003). The merging of supply chains into networks combines vertical and horizontal inter-organizational dimensions to ensure the continuity and fluidity of physical flows, from suppliers to consumers (Fabbe-Costes, 1997). In addition, the management of co-opetitive relationships enables rival firms to work together by balancing co-operative and competitive behaviors (Le Roy, 2003).

The lasting nature of such emerging patterns, where direct competitors in a given market collaborate durably in logistical matters, now interests both professionals and scholars. Existing theoretical contributions do not really explain under what conditions pooling approaches arise between competitors. If "why" seems to be the subject of a number of works, "how" remains particularly obscure to this day. This paper wishes to highlight the importance of information systems (IS) in the integration of supply chains (Fabbe-Costes, 2007), and in the spreading of collaborative logistical practices between direct competitors. In other words, we would like to underline the part played by IS in the formulation and management of co-opetition strategies.

However, our vision of the steering of supply chain networks from a literature review is partial. However, there is limited literature on what actually drives supply chain networks. If several firms embark on collaborative projects with competitors, it is without doubt because their decision makers maintain a favorable relationship climate due to powerful social ties. This is a fact relatively little known and studied, except by Borgatti & Li's (2009). We would like to highlight the part played by IS in the dissemination of co-opetitive strategies within supply chain networks. The dimensions examined relate to the integration of supply chains and co-opetition. The paper first tries to understand how IS can bring answers to issues raised by the integration of supply chains before identify the links existing with co-opetitive strategies. Finally we widen the analysis by pointing out that, for increased efficiency, co-opetitive strategies require the understanding of the formalized social ties between decision makers.

SUPPLY CHAIN INTEGRATION

Zouaghi & Spalanzani (2010) define a supply chain as a "*hierarchic and dynamic network with processes, made of a set of firms from the first supplier to the final customer, linked by upstream and downstream flows (physical, information, financial and knowledge flows) and by relationships at various levels, and formed in order to satisfy customers through better coordination and integration, and also through greater flexibility and reactivity*"*.* The interest for supply chains is directly due to vertical disintegration policies, associated with outsourcing approaches launched as early as the 1980s. Outsourcing naturally leads to supply chain integration (Dumoulin *et al.*, 2000), so as to ensure a maximum supply chain continuity and improved control. Firms must try to adhere to SCM principles if they want to form a coherent whole when in close interaction but legally independent.

In any supply chain, the efficient directing of physical flows —for the right products to reach the right place at the right time in sufficient quantities— is associated with a sophisticated management of information flows. The perfect connection of firms between themselves (Christopher, 2010), particularly at IS level, appears as an absolute necessity for a smooth and continuous flow circulation. It is no longer a case of optimizing flows inside one organization, but flows between organizations (Lambert & Cooper, 2000; Mentzer *et al.*, 2001). Supply chain integration at inter-organizational level is increasingly studied, as it is complex and worthwhile for supply chain members. Major studies bear on integration characteristics, stakes, key factors of success and, as developed later on in the paper, the role of IS.

Integration characteristics vary depending on integration extent and the elements integrated. Fabbe-Costes (2007) distinguishes five levels: inter-organizational integration, limited inter-organizational integration, extended inter-organizational integration, integration between supply chains (also called "network"), and societal integration. This author points out the existence of four interdependent integration layers: flows (physical, information and financial); processes and activities; systems and technologies; players (organizations). The issues of integration are mainly to overcome the scattering of the partners' activities (production, storage, distribution), to erase the time gap to ensure flow smoothness and continuity (Paulraj & Chen, 2007) and finally to limit operational malfunctions (costs, delayed deliveries, stock-outs), that have a noxious effect on customer satisfaction.

To take up the challenge of logistical integration, several essential elements are needed: IS implementation, coordination, management's involvement, organizational factors and the nature of relationships between players. IS implementation becomes a "*powerful tool for coherence making up for disseminated logistics*" (Fabbe-Costes, 1997). The extent to which physical flows are steered by information flows necessitates IS be interconnected amongst different supply chain members. An IS is "*an organized set of resources (…) to acquire, process, and store information in and between organizations"* (Reix, 2005). For Reix (2005), IS have an information, technological and organizational dimension. In an inter-organizational context, the major feature of the IOS is to be involved in the sharing and processing of data from different organization.

INFORMATION SYSTEMS AND THE INTEGRATION PROCESS

Coordination is supported by data and knowledge exchanges at both intra-organizational and inter-organizational levels (Fabbe-Costes & Lancini, 2009), with the notion that physical flow management is "*a necessarily shared process between several interdependent players*" (Paché, 1997). Mutual adjustment, standardization and direct supervision by management may form suitable coordination modes (Reix, 2005). A neutral intermediate player, such as 3PL, may also assume the part (Stefansson & Russel, 2008), of integrator of supply chain networks, capable of taking charge of physical interfaces and information interfaces between all players. Aubert & Dussart

(2002) identify three types of interdependence between organizations having an influence on the nature of IS itself: grouped interdependence, sequential interdependence and reciprocal interdependence. These authors note that when the sharing of data increases among partners, the potential for conflicts also increases.
The involvement of top managers consists in thinking in terms of integration of shared activities and objectives with business partners (Spalanzani & Evrard-Samuel, 2007). This ensures alignment between the overall strategy, the logistical strategy and IS (Henderson & Venkatraman, 1993; Fulconis *et al.*, 2011). A high involvement of top management legitimates the desire to adapt each individual IS to connect it to their business partners' IS, to modify original logistical patterns and finally to share the potential benefits of the new organization (Fabbe-Costes, 1997). In the end, supply chain integration depends on organizational factors such as corporate vision, organizational compatibility and process interoperability (Zouaghi & Spalanzani, 2010).
For all elements to operate as a whole, it is essential to manage tensions between supply chain members and overcome communication barriers associated with physical, economical, strategic and social criteria. Conflicts, opportunist behaviors, the lack of trust and sharing of a common framework, information asymmetry and the lack of a physical structure to collaborate will limit the scope of supply chain integration (Fabbe-Costes & Lancini, 2009). A number of academic works underline the part that IS could play in supply chain integration. IS represent an operational challenge when allowing the whole to be operational, and a strategic challenge when allowing networks members to work together (Reix, 2005). As an element of logistical management, IS appear as instruments, i.e. functions to perform, and also as a model, i.e. a structure to organize.
Primarily IS perform a communication role as they disseminate a set of data within the organization (Reix, 2005) (see, for instance, the Mitsubishi logistics information system—Figure I). Secondly, IS fill a large place in supply chain optimization and performance by improving the rapidity and reliability of information flows and consequently physical flow circulation performance. Hence, IS participate in reducing uncertainty as to the nature and quantity of flows to activate (Fabbe-Costes, 2007). IS also represent an adaptability vector for organizations through instantaneous data exchange (Jaziri & Kalika, 2006). IS improve coordination with the sharing of data (Zouaghi & Spalanzani, 2010), and an efficient management of interfaces (Fabbe-Costes, 1997).

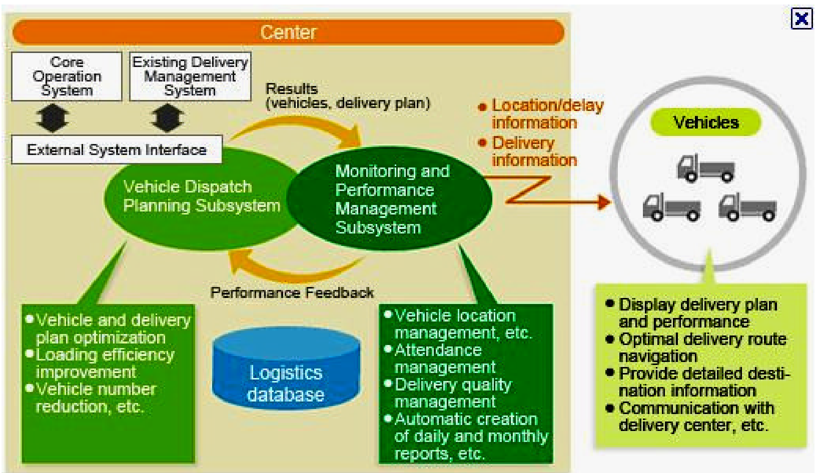


Figure I: The Mitsubishi logistics information system
(http://www.mitsubishielectric.com)

IS as a construction offer both a space representation (organization of activities) and a time representation (management history) of supply chains. This construction has an "organizing" potential (Jaziri & Kalika, 2006), which will supply a framework to inter-organizational relationships. For Arnaud & Elamrani (2009), IS have a structuring effect

on the degree of formalism and intensity of relationships between supply chain members. Reix (2005) suggests, by referring to the interactionist vision, that there exists reciprocal influences between the structure and the players' actions. IS are the result of the players' actions, but they will in turn facilitate (instrumental function) and hinder (model function) the players' action.
Finally, IS offer a strategic challenge by formalizing contacts between supply chain members (Tran, 2007). IS facilitate cooperation by reducing tensions and sources of conflicts (Paulraj & Chen, 2007), especially when their management is entrusted to a neutral intermediate party (Aubert & Dussart, 2002). IS thus participate in the construction of a collective intelligence (Fabbe-Costes, 1997), even of the control of the logistical network (Boulay & Isaac, 2007), and help make the joint decision to steer and manage possible malfunctions. IS may represent a collective competitive advantage (Zouaghi & Spalanzani, 2010), but also an obstacle to leaving the partnership, due to investments in the implementation of the system (Aubert & Dussart, 2002).

CO-OPETITION MANAGEMENT

A number of authors, e.g. Bengtsson & Kock (2000), Kotzab & Teller (2003), Zhang (2006), and Osarenkhoe (2010), stress the existence of powerful co-opetition approaches in supply chains. Competing firms may cooperate to carry out given logistical activities (production, purchasing, distribution), while remaining competitors in the same market. Bengtsson & Kock (2000) define co-opetition as a dyadic and paradoxical relationship arising when two firms cooperate in some activities and compete in others at the same time (see Figure II). Dagnino & Padula (2002), differentiate dyadic co-opetition from network co-opetition when co-opetition relationships involve several firms at the same time.

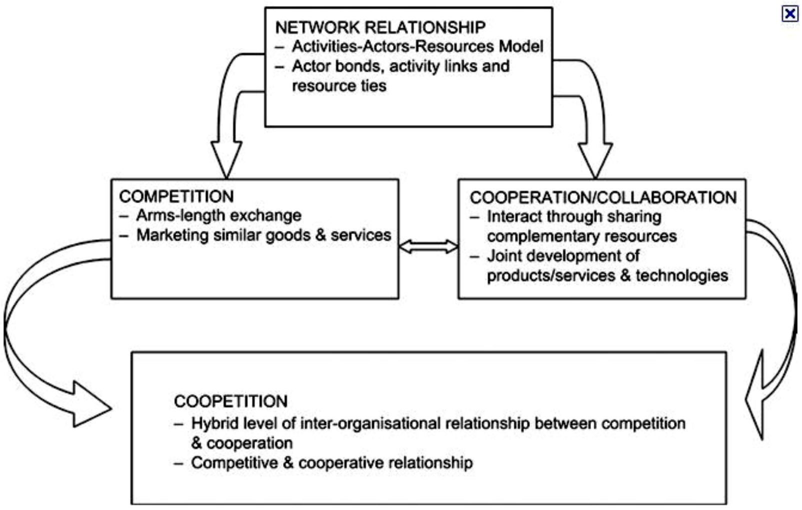


Figure II: Inter-firm dynamics between competition and cooperation
(Adapted from Osarenkhoe, 2010)

Co-opetition means benefiting from the advantages of both co-operation and competition (Bengtsson & Kock, 2000; Dagnino *et al.*, 2007), provided competitive and co-operative behaviors are adopted at the same time. This co-operation and competition ago-antagonistic relationship gives a paradoxical nature to co-opetition (Dagnino *et al.*, 2007), and presents a number of risks to competitors. The major risks are associated with individual/collective conflicts of interest (knowledge sharing, sharing of gains and losses), access to strategic data for competitors and opportunistic behaviors from all parties (Baumard, 2006; Gnyawali & Park, 2009).
The risks of co-opetition are inherent to the nature of the strategy. In the case of excessive co-operation, agreement would be damaging, and in the case of excessive competition, the intensity of conflicts would cancel all potential advantages of the said strategy. Risks lie in an excessive application of one of these approaches, as this would

end up in either pure co-operation, or pure competition, which is in contradiction with the strategy. If maintaining co-operation between competitors is a major stake in a context of co-opetition, maintaining competition is also essential for the strategy to endure. The management of tensions between competitors is a determining element, but provided the intensity of competition is not reduced. This is why the success of co-opetition relies on a subtle management of interdependencies between competitors in order to achieve a balance between co-operation and competition (Le Roy, 2003), and thus achieve the expected objectives.

The academic literature identifies three modes of management in co-opetition supply networks all of which separate co-operative behaviors from competitive behaviors (Bengtsson & Kock, 2000; Dumez & Jeunemaître, 2006). The first mode of management is sequential interdependence, or a temporal separation of co-operation and competition. The second mode is direct interdependence among competitors, co-operation and competition being functionally separated (different functions and activities) or separated in space (different geographical areas). The third and last management mode is indirect interdependence where the cooperative aspect of management is entrusted to a neutral third party.

Organizational factors such as supervising, the socialization process, commitment, the nature of relationships, the communication mode and IS, will improve co-ordination and reduce potential conflicts (Kotzab & Teller, 2003; Luo, 2005; Chin *et al.*, 2008). Issues of knowledge sharing and co-ordination modes are also important (Levy *et al.*, 2003). In parallel, structural factors such as the alliance design and management condition the nature of benefits and risks (Ritala, 2009); rules shape and organize relationships between individuals (Baumard, 2006), and the implementation of standards and processes allow the sharing of a corporate vision (Kotzab & Teller, 2003).

Information, and particularly its exchange and sharing between supply chain members, seems to represent a significant part of co-opetition relationship management. Information has a dual character as it sustains both individual behaviors (information secrecy) and collective behaviors (information exchange) (Le Roy & Guillotreau, 2002). The implementation of IS between competing firms must take into account the dialectics between confidential individual information and shared collective information (Benda, 2004), that is to say, alternate between opacity and transparency.

A REFLECTION ON SOCIAL TIES

The dual character of logistical information leads to wondering whether IS may integrate both co-operative and competitive behaviors (Tran, 2007). Hence, an examination of the role of IS within co-opetition strategies in supply chains is warranted. In other words, what is the place of IS in the formulation of co-opetition strategies in supply chains, and can they contribute to the management of the paradoxical nature of co-opetition? This is the issue supporting Corbière *et al.*'s (2010) research. In their view, the quality of the data fed into IS has a direct impact on a possible pooling of logistical resources, its extent and its dissemination speed.

If such questioning is legitimate, it minimizes inter-personal communication between individuals in order to efficiently drive co-opetitive strategies. The social ties existing between decision makers in each of the firms involved will certainly have a positive impact on the implementation of a shared logistical project, even if decision makers have to report first to their own respective companies (and particularly their shareholders). The desire to develop a collaborative project with a competitor, for example take part in a shared pool of suppliers, means that individuals are going to commit themselves to an organizational decision in the long term. They hence also commit to a rapprochement process with competitors which is made easier when they belong to the same social networks, such as the old students' associations of business schools.

Two major questions emerge: (1) what is the role of the social network in the strategic decision making process of co-opetition; and (2) how can social networks be involved in the management of paradoxes induced by co-opetition? In a recent contribution, Hiesse & Paché (2010) investigated the recent logistical pooling practices between

competing suppliers (manufacturers) in the French retailing sector. Manufacturers have adopted co-opetitive strategies by collaborating on logistical activities while competing in the market in front of the final consumer. The investigation is based on an exploratory case study with data collected from 15 semi-structured interviews conducted with manufacturers, 3PL and consultants involved in pooling practices.
The findings underline the influence of the social networks on the emergence of co-opetitive networks and on the nature of the social processes induced (i.e. allowing connections between members, modes of co-ordination, and modes of control). It is thus possible to see that social ties impact the success or failure of the emergence of co-opetitive strategies. Collaboration between competitors can be facilitated or inhibited by the sharing process of previous experiences between potential members of the network such as common careers, trainings, or meetings through associations of professionals. Furthermore, social ties support the creation of trustful relationships between competitors, reducing the risks of opportunistic behaviors as well; trust becomes a co-ordination and control mode to improve the management of interdependencies between competitors. The balance of the co-opetitive relationship can be disturbed by internal factors (opportunism) or by external factors (a new member). Social ties can thus help the partners to maintain the balance. Pre-existing social ties between members of the network influence the way the competitors interact in their daily business transactions.
In a research program, we can promote two different insights: the role of the social ties in the emergence and management of co-opetitive strategies within supply chains; the importance of the social dimension as any other economical or relational dimension to explain the efficiency of co-opetitive networks. To expand on the theory of structuration (Giddens, 1984), and on Reix's (2005) reflections, it seems interesting to position the understanding of co-opetition into an iterative pattern stabilized by the construction of IS to direct inter-organizational relationships. This structure is over-determined by the behaviors of individuals who, in their turn, can adjust the IS; the approach must be considered as iterative, as it has to take the social ties connecting decision makers into account.
Hiesse & Paché's (2010) contribution does not ask directly how embedded supply chain activities are within a social perspective, unlike Borgatti & Li (2009) who focus on this very issue : for them, it is essential to take into account the importance of socialization processes in the emergence and in the implementation of co-opetitive strategies for managers. The socialization process, based on an interpersonal dimension, appears as a critical key success factor. When social ties do not pre-exist between members, the process can be driven by a third party. This third party will facilitate the emergence and the implementation of co-opetitive strategies. It opens a new field of investigation about the legitimacy of the third party. Does he/she have the necessary competences to stimulate the creation of social ties between future members? It is therefore indispensable to go beyond the conventional vision considering that IS, as they exist, are facilitators of co-opetitive strategies.

CONCLUSION

The academic literature often privileges the analysis of IS to approach co-opetitive strategies, as there is an obvious difficulty in collecting data to study co-opetition relationships. Analyzing IS is a means of obtaining a representation of supply chain networks making it easier to understand exchanges between firms and particularly the co-opetition management modes. IS analysis supplies much information on the players involved, the areas for co-operation and competition, management procedures, the nature and frequency of data exchanged, the co-ordination, decision making, reporting and cost control modes. The various management levels involved in co-opetition strategies and also the presence of middlemen are easily identifiable from the examination of IS. Without ignoring this reality, the paper wishes to underline the indubitable significance of social ties in the success of co-opetitive strategies. This is an emerging subject asking for further investigation by mobilizing other literature research fields, particularly sociology and social psychology.

REFERENCES

Arnaud N. & Elamrani R. (2009) *Complémentarité de la collaboration électronique et de l'investissement relationnel: étude de cas exploratoire d'un SIIO dans le secteur du meuble*, Document de travail No. 2009-01-013, Groupe de Recherche Angevin en Economie et Management, Angers.

Aubert B. & Dussart A. (2002) *Systèmes d'information inter-organisationnels*, Rapport Bourgogne 2002-RB-01, Centre Inter Universitaire de Recherche en Analyse des Organisations, Montréal.

Baumard P. (2006) "Connaissance tacite et formation des stratégies collectives: une étude de cas", *in* Yami S. & Le Roy F. (Eds.), *Stratégies collectives: rivaliser et coopérer avec ses concurrents*, Editions Management & Société, Caen, 101-134.

Benda J. (2004) "L'utilisation dune place de marché électronique: une stratégie collective contre des stratégies individuelles? Une étude exploratoire de trois cas", *Actes de la 13e Conférence de l'AIMS*, Le Havre, 1-25 (CD-rom).

Bengtsson M. & Kock S. (2000) "Coopetition in business networks–To cooperate and compete simultaneously", *Industrial Marketing Management*, 29(5), 411-426.

Borgatti S. & Li X. (2009) "On social network analysis in a supply chain context", *Journal of Supply Chain Management*, 45(2), 5-22.

Boulay J. & Isaac H. (2007) "Contrôler les réseaux d'entreprise avec les technologies de l'information", *Revue Française de Gestion*, 170, 103-115.

Chin K., Chan B. & Lam P. (2008) "Identifying and prioritizing critical success factors for coopetition strategy", *Industrial Management & Data Systems*, 108(4), 437-454.

Christopher M. (2010) *Logistics and supply chain management*, FT Prentice Hall, Harlow, 4th ed.

Dagnino G.-B. & Padula G. (2002) "Coopetition strategy: a new kind of interfirm dynamics for value creation", *Proceedings of the 2nd EURAM Conference*, Stockholm, 1-32 (CD-rom).

Dagnino G.-B., Le Roy F. & Yami S. (2007) "La dynamique des stratégies de coopétition", *Revue Française de Gestion*, 176, 87-98.

De Corbière F., Durand B. & Rowe F. (2010) "Effets économiques et environnementaux de la mutualisation des informations logistiques de distribution: avis d'experts et voies de recherche", *Management & Avenir*, 39, 326-348.

Dumez H. & Jeunemaître A. (2006) "Etudier la combinaison affrontement et coopération: la notion de séquence stratégique multidimensionnelle", *in* Yami S. & Le Roy F. (Eds.), *Stratégies collectives: rivaliser et coopérer avec ses concurrents*, Editions Management & Société, Caen, 37-47.

Dumoulin R., Meschi P.-X. & Uhlig T. (2000) "Management, contrôle et performance des réseaux d'entreprises: étude empirique de 55 réseaux d'alliances", *Finance Contrôle Stratégie*, 3(2), 1-29.

Fabbe-Costes N. (1997) "Pilotage logistique: quel système d'information et de communication?", *in* Aurifeille J.-M., Colin J., Fabbe-Costes N., Jaffeux C. & Paché G. (Eds.), *Management logistique: une approche transversale*, Litec, Paris, 111-144.

Fabbe-Costes N. (2007) "La gestion des chaînes logistiques multi-acteurs: les dimensions organisationnelles d'une gestion lean et agile", *in* Paché G. & Spalanzani A. (Eds.), *La gestion des chaînes logistiques multi-acteurs: perspectives stratégiques*, PUG, Grenoble, 19-43.

Fabbe-Costes N. & Lancini A. (2009) "Gestion inter-organisationnelle des connaissances et gestion des chaînes logistiques: enjeux, limites et défis", *Management & Avenir*, 24, 123-145.

Fulconis F., Paché G. & Roveillo G. (2011) *La prestation logistique: origines, enjeux et perspectives*, Editions Management & Société, Caen.

Giddens A. (1984) *The constitution of society: outline of the theory of structuration*, Polity Press, Cambridge.

Gnyawali D. & Park B.-J. (2009) "Co-opetition and technological innovation in small and medium-sized enterprises: a multilevel conceptual model", *Journal of Small Business Management*, 47(3), 308-330.

Henderson J. & Venkatraman N. (1993) *Strategic alignment: a model for organizational transforming via information technology*, Oxford University Press, New York (NY).

Hiesse V. & Paché G. (2010) "Logistique mutualisée: une nouvelle architecture organisationnelle dans les canaux de distribution", *Economies et Sociétés*, Série Systèmes agroalimentaires, 32, 1513-1533.

Jaziri F. & Kalika M. (2006) "Le co-alignement des technologies et systèmes inter-firmes: étude empirique dans le secteur des services logistiques en France", *Systèmes d'Information & Management*, 11(1), 45-83.

Kotzab H. & Teller C. (2003) "Value-adding partnerships and co-opetition models in the grocery industry", *International Journal of Physical Distribution & Logistics Management*, 33(3), 268-281.

Lambert D. & Cooper M. (2000) "Issues in supply chain management", *Industrial Marketing Management*, 29(1), 65-83.

Le Roy F. (2003) "Rivaliser et coopérer avec ses concurrents: le cas des stratégies collectives agglomérées", *Revue Française de Gestion*, 143, 145-157.

Le Roy F. & Guillotreau P. (2002) "Contester la domination des leaders de marché en changeant les règles du jeu: le cas de l'industrie thonière française", *Management International*, 6(2), 29-41.

Levy M., Loebbecke C. & Powell P. (2003) "SMEs, co-opetition and knowledge sharing: the role of information systems", *European Journal of Information Systems*, 12(1), 3-17.

Luo Y. (2005) "Toward coopetition within a multinational enterprise: a perspective from foreign subsidiaries", *Journal of World Business*, 40(1), 71-90.

Mentzer J., DeWitt W., Keebler J., Min S., Nix N., Smith C. & Zacharia Z. (2001) "Defining supply chain management", *Journal of Business Logistics*, 22(2), 1-25.

Osarenkhoe A. (2010) "A coopetition strategy—a study of inter-firm dynamics between competition and cooperation", *Business Strategy Series*, 11(6), 343-362.

Paché G. (1997) "Logistique de distribution: le poids prépondérant des détaillants", *in* Aurifeille J.-M., Colin J., Fabbe-Costes N., Jaffeux C. & Paché G. (Eds.), *Management logistique: une approche transversale*, Litec, Paris, 33-69.

Paulraj A. & Chen I. (2007) "Strategic buyer-supplier relationships, information technology and external logistics integration", *Journal of Supply Chain Management*, 43(2), 2-14.

Reix R. (2005) *Systèmes d'information et management des organisations*, Vuibert, Paris, 5th ed.

Ritala P. (2009) "Is coopetition different from cooperation? The impact of market rivalry on value creation in alliances", *International Journal of Intellectual Property Management*, 3(1), 39-55.

Spalanzani S. & Evrard-Samuel K. (2007) "L'absorption de l'incertitude dans la chaîne logistique: passé, présent et futurs", *in* Paché G. & Spalanzani A. (Eds.), *La gestion des chaînes logistiques multi-acteurs: perspectives stratégiques*, PUG, Grenoble, 45-66.

Stefansson G. & Russel D. (2008) "Supply chain interfaces: defining attributes and attribute values for collaborative logistics management", *Journal of Business Logistics*, 29(1), 347-359.

Tran S. (2007) "TIC et jeu concurrentiel: le cas des places de marché électroniques", *Revue Française de Gestion*, 173, 157-169.

Zhang D. (2006) "A network economic model for supply chain versus supply chain competition", *Omega*, 34(3), 283-295.

Zouaghi I. & Spalanzani A. (2010) "Les antécédents relationnels inter-organisationnels de l'alignement des systèmes d'information au sein d'une supply chain", *Proceedings of the 8th International Conference on Logistics and Supply Chain Management Research*, Bordeaux, 1-25 (CD-rom).

LEAN ACROSS CULTURES: STATE-OF-THE-ART

Cristina Machado Guimarães, José Crespo de Carvalho
ISCTE- Lisbon University Institute

ABSTRACT
Lean thinking "translation" from manufacturing to services settings is a topic with growing interest among academics and practitioners in operations management (om) field (holm and ahlström, 2010, jones, 2006). Brandao de souza (2009) updates that evolution regarding the lean principles application to healthcare and challenges researchers to evaluate lean healthcare under a more critical perspective contextual variables of lean deployment have to be considered (dal pont, 2010; hines et al, 2008). Scarce but important review articles present the deployment extention of lean thinking in healthcare settings (mazzocato et al, 2010). However, all reviews seam to be surgical in scope presenting only success cases and narrow in extension not trying to cover different national cultures context.

Purpose: It seems to be the first time evidence on lean practices in healthcare sector has been systematically collected and structured in order to understand the reality beyond the multi cultural trend. Understanding lean practices across the world considering cultural aspects might help organizations not only to find a suitable implementation model as to deal with global partners with a better knowledge of the state-of-the-art in lean thinking adoption.

INTRODUCTION

Applying Lean in healthcare services has been the most visible and recent trend in services industry (Holm and Ahlström, 2010, Jones, 2006). However, is "Lean" in healthcare just a buzzword or a sustainable enterprise process improvement system?

Presented as an antidote to *muda* (waste) (Ohno, 1988), converting *muda* into value, *Lean thinking* was coined by Womack et al (1990) as a five principle improvement philosophy: (i) specify value, (ii) identify the value stream, (iii) make the value-creating steps for specific products flow continuously, (iv) let the customers pull value from the enterprise, and (v) pursue perfection. These same principles prevailed since Taiichi Ohno's seven wastes struggle throughout the Lean concept evolution. Research has been strongly concentrated in Lean manufacturing and only recently the discussion on Lean production included the concept's relation to Six Sigma and Total Quality Management (TQM) (Liker, 2004). Hines et al (2004) present the evolution of Lean concept highlighting the shifting of focus from quality in early 1990s to customer value with the appliance to services sector, from 2000s onwards (Hines et al, 2008).

Scarce but relevant review literature presents the extension of Lean deployment in healthcare settings. However, all reviews seem to be surgical in scope and narrow in geography, presenting only success cases and not trying to cover different national cultures context.

Being aware of the different corpuses of literature produced by industrial and academic methods (scientific and grey) this literature review aims to bring together insights from operational management, quality management and supply chain management and provide new agenda for future research considering cultural issues.

MAPPING LEAN DEPLOYMENT IN HEALTHCARE

Healthcare services waited sixty years for manufacturing lessons and rush in to implement these improvement principles and tools. These attempts have been scope of several review articles bringing a narrow or a broader view to the comprehension of the phenomenon of lean implementation in healthcare settings. Young and McClean (2008)' s review, stressing the difficulty of "value" definition in healthcare, challenges future research proposals to consider three critical dimensions of value: clinical, operational and experiential in the assessment of lean gains. Winch and Henderson (2009) question the theoretical basis from which the lean deployment in healthcare is derived stressing the need of evidence for long-term benefits related to patient outcomes, in a critical tone but not providing a systematic review. Brandão de Souza (2009)'s systematic and critical review updates the concept evolution regarding the Lean principles application to healthcare and suggests a taxonomy for classifying the literature giving a first glance of geographic evidence and bringing the issue of sustainability of lean findings linked to the need of deeper studies regarding cross-organizational (strategic and operational) lean deployment.

The Poksinska (2010)'s review disclosures the lean scope intervention main areas in healthcare confined only to the first three (from the five) Lean Thinking principles, the most usual roadmap implementation, barriers and enablers in healthcare setting and presents two main areas outcomes: in the performance of the health care system and in the development of human resources and work environment.

A realist review is presented by Mazzocato et al (2010) of successful appliance of lean thinking in healthcare that influence patient care. Changes are presented through a logic in which common contextual aspects interact with lean intervention different components and trigger four different change mechanisms: (i) understand processes to generate shared understanding;(ii) organise and design for effectiveness and efficiency; (iii) improve error detection to increase awareness and process reliability; and (iv) collaborate to systematically solve problems to enhance continual improvement. Although only success cases are studied, which can indicate a bias, the sustainability issue was absent in this review, lacking a long term view of changes. The authors explain this constraint due to an immaturity of the field for conducting a realist review.

Success and factors inhibitors are the main focus of Sobek and Lang (2010) review, presenting the range of manufacturing translated tools applied and the idiosyncrasies of healthcare organizational culture that ask for a better adaptation to healthcare language.

There are contextual variables of Lean adoptions in services (Dal Pont, 2010) and context specificities in healthcare services. One of the specificities regards the sociotechnical aspects when implementing lean thinking (Joosten et al, 2009), apart from specific operational aspects from healthcare organizations. While the former lack deep research, the latter have been subject of more thorough concern by academics and practioners. Towill and Christopher (2005) framed the analysis of healthcare pipelines in lean and agile paradigms showing that the principles of supply chain design used in industrial and commercial contexts provide a suitable "architecture" within a healthcare delivery context and present taxonomy to redesign healthcare delivery systems based on multiple pipelines. Another taxonomy is presented by Burgess et al (2010) proposing six different intensities of lean adoption going from "tentative" to "systemic" in 152 Hospitals Trusts in UK linking to performance criteria, opening a case study path for deeper research addressing Lean cultural issues.

ORGANIZATIONAL AND NATIONAL CULTURAL GROUND OF LEAN DEPLOYMENT

"Lean thinking", a term coined by Americans, James Womack and Daniel Jones (1996) studying the Toyota Production System. A system influenced by Sakichi Toyoda' son, Kiichiro, who travelled to the United States to study Henry Ford's system in operation, learned from Ford's mistakes and replaced, with his chief process engineer Ohno, maximum for minimum lot sizes and minimum set ups for "just-in-time" production (Liker, 2004). Two different countries, with different positions in the cultural values dimensions assessment: Power Distance, Uncertainty Avoidance and Individualism (resembling only in Masculinity) (Hofstede, 1985), contributed differently for the same management philosophy. Hofstede and Minkov (2010) added a fifth cultural dimension: Long versus short term orientation and ranked 23 countries based in the Chinese Values Survey and 44 countries based in World Values Survey. Japan occupies the 4 th position in the first rank and the 3rd in the rank composed by the 44 countries showing a strong long-term orientation. Conversely, in both ranks, not surprisingly, USA occupies a place in the last third of the list.

According to Wong (2010),when looking at Lean ingredients as flow shop production, stress on quality, and use only reliable and thoroughly tested technology, they manifest the cultural characteristic of collectivism. Likewise, continuous improvement expresses the cultural characteristic of masculinity. While empowerment shows the obvious power distance in the organization, the elimination of the uncertainty on site and solving problems in time through visual control, use only reliable and thoroughly tested technology, and level out the workload (*Heilinka*) shows that the cultural characteristic is highly uncertainty avoidant. Also the characteristics contained in lean production, such as determined will, shame, and thrift, go for future long-term vision with tradition and being obedient to achieve final goals, are basic value points and attitudes in supporting lean production.

Can the "Toyota Way" adoption by several others countries with different implicit models of organizations be understand as an acculturation process? Can we see all Lean deployments as cultural transformation?

Culture can be defined at four main levels: society, organizational, small group and professional (Hofstede, 2000). The author suggests that national and professional cultures of an organization's members can dominate organizational culture, being the last much more superficial than the formers. One can easily chose another organization but not so easily another country. More, being the "shared perceptions of daily practices" the core of an organization's culture, the simple imitation of superiors' practices without perceiving it in the same way means that both sides don't share the same culture. So how can one change a culture that is not fully understood? According to Hosftede (2000), working on members perception in different organizational cultural dimensions: (i) process vs results orientation; (ii) employee vs job orientation; (iii) parochial vs professional; (iv) open vs closed; (v) loose vs tight control; and (vi) normative vs pragmatic, through daily practices. In this perspective, leadership plays the main role. McLaurin (2006) addresses leadership as a critical success factor and distinguishes three national styles: American, European and Japanese culture leadership. Hofstede (1998) posits that the minds of top managers are less complex than their organizations and their decisions reflect their managerial group subculture, whether it fits in a production, bureaucratic or a professional kind. Cultural alignment has to cope with multiple subcultures. In a macro-level it is possible to identify different hierarchies of business goals importance between leaders from different cluster of countries Hofstede (2004). According to Thanopoulos and Leonard (1996), cultural factures are the main constraint in adoption of Japanese management style. Through a review of more than 100 publications on business in Japan, the main three characteristics of Japanese management thinking: harmony and group loyalty, consensus decision making, and life-time employment cannot be used as recipes for success for being too idiosyncratic.

The Japanese cultural success factors have been studied by several authors. Drucker (1971), Horvath and McMillan (1980) enhanced the adaptability as success factor. Drucker (1987) and Vogel (1978) stressed the dialogue between Entrepreneurs and Government. Others (Marengo, 1979; Ouchi, 1981; Weiss, 1984) underlined the group solidarity. And Ouchi and Johnson (1974) enhanced the paternalistic system and the population homogeneity as the cultural success factors. Analysing the differences between Japanese and American management, Fox (1977) concludes that American organizations failed in the understanding of the *Ringi* system and in applying Japanese management, mostly due to the individualism characteristic.

Emiliani (2006), through a historical view of Lean Management adoption in USA since 1979, describes how the Japanese Lean principle "respect for people" was not understood by organizations only focused in "continuous improvement".

Takeuchi et al (2008) present Toyota success though a set of contradictions: (i) moving slowly, but taking big steps; (ii) growing steadily but showing paranoid fear of bankruptcy; (iii)running efficient operations but using employees' time in apparently wasteful ways; (iv) being frugal but splurging on key areas; (v) simplifying internal communications while building complex social networks; and (vi) maintaining a strict hierarchy while encouraging employees to push back and criticise constructively. Toyota's DNA is marked by impossible goals, local customization and a great deal of experimentation as the main forces of expansion. At the same time its organizational culture is coined by integration forces such as values from the founders, retention of talents with a strong commitment to respect for people and an open communication.

Toyota's executives are willing to listen and learn, constantly drive for improvements, comfortable with working in teams with ability to quickly act and solve a problem. And above all, these executives are *senseis*, coaching other employees without loosing modesty. However, Schonberger (2010) posits that Toyota has been losing its leanness, and consequently its performance due to several causal factors, including: (i) a strategic shift from conservative ways to all-out for global growth; (ii) years of industry and general-public adulation, leading to complacency; (iii) an apparently strong but actually fragile culture relating to decades of insularity in the confines of its Toyota-City home base—while most competitors had gained global experience years earlier; (iv) closed-mindedness with regard to best practices developed elsewhere; (v) loss of customer focus; (vi) insufficient human resources to get and keep its fast-growing global population trained in and practicing the "lean core" and newly developing essentials of process excellence.
Some authors (Radnor and Walley 2008; Hines and Lethbridge 2008; McQuade 2008; Scorsone 2008) point that different corporate cultures can inhibit Lean implementation. Lean is not just a technological system but also a management philosophy that serves the whole company, which requires consensus on corporate culture. Thus, the shared assumptions, beliefs and values that define each organizational culture (Schein, 1992) can make the difference between a company success or failure (Goffee and Jones, 2003). National culture plays an important role in corporate culture construction (Adler 1986; Doktor 1990; Hofstede 1994) and the inconsistence of national culture increases the difference of the organizational cultures (Oudenhoven 2001) and hinders the transfer of managerial philosophies or production systems (Wong, 2010).
The long- versus short-term orientation and the way respect for people is seen in every country might lead to different consistencies in lean deployment. Hines (2010), among others, posits that the pure and simple tool deployment to achieve quick-wins lead to a short term Lean results and often returns to "the comfort zone" whilst systematic Lean approaches of culture changes shows long-term results. Hines et al. (2008) suggest that what makes "Lean stick" is leadership. Dal Pont (2010), analysing Lean adoption techniques in services, define "enablers" of Lean deployment variables as: (i) process or/and service divisibility, serenity, (ii) loyalty and leadership and (iii) information technology (IT) skills. Conversely, define as inhibitors: (i) knowledge, (ii) customer contact, (iii) corporate culture, (iv) complexity and (v) autonomy. Each of these variables' findings requires in-depth studying and testing, namely in healthcare setting.
In spite of the globalization, each national culture still owns its uniqueness for its particular core value. Taking one of the most recent sectors embracing the "Lean Journey", Healthcare, this study' challenge was to update findings regarding cultural (national and organizational) aspects of Lean deployment in an embryonic but growing stage of this sector.

METHODOLOGY

A systematic search in electronic databases (ABI/Inform, B-On, PubMed) was conducted with the purpose of gather information and examples from both scientific and grey literature (Farace, 1998) that could show a full picture of lean healthcare practices emphasizing the cultural (national and organizational) aspects. We have excluded articles concerning hybrid approaches (as "Lean Six Sigma") and included all articles that reported successful or not successful lean deployments in healthcare organizations, in peer-review and grey publications using key words: "lean thinking"; "lean healthcare"; "Toyota Production System" and "Lean Services". Books were also excluded for presenting a broader case analysis extension when our goal was categorization of the main scope, which is more clearly in articles. A cross-reference search encompassing the eligible first selection was carried out. Data were collected in two Excel spreadsheet, one following a categorization according the publications taxonomy of Brandão de Sousa (2009), and the other covering the main findings categories: outcomes, measures, risks, implementation barriers and enablers, and sustainability factors of lean applications in healthcare.

RESULTS

From the electronic search resulted 115 records, 19 of which not eligible. To the 96 retrieved, 11 articles were added resulting from the reference lists. In total 83 eligible articles concerning Lean deployment in Healthcare in a specific country context and another 2 articles in cross-countries context were consider. After full text assessment we arrived to the following distribution.

Lean Healthcare Literature Taxonomy Classification (Brandão de Sousa, 2009)

	CASE STUDIES				THEORETICAL	
COUNTRY	Manufacturing -Like	Managerial and Support	Patient Flow	Organizational	Methodological	Speculative
USA	(3)(6)(9)(13)(17)(19)(22)(23)(24)(26)(27)(28) (33)	(5)(7)	(4)(15)(25)(29)(31)	(2)(11)(12)(12)(14)(21)(30) (32)	(1)(18)(20)	(8) (10)(16)
Canada	(35)		(34)	(36)		
UK	(42) (47) (57)(60)	(43)	(48)(45)(59)	(38) (39) (40) (41)(45)(46)(49)(51)(52)(53)(58) (61)	(37) (50) (55) (56)	(44)
Netherlands			(62)			
Sweden	(67)		(63)(64)(65)(68)	(66)		
Germany		(69)				
France	(70)					
Spain		(71)				
Italy	(72)					
Denmark			(73) (74)			
Australia			(75)(76)(77)(78)		(79)	
Sri Lanka	(80)					
Iran	(81)					
Brazil	(82)					
Portugal					(83)	
USA/Australia/ Canada				(84)		
Finland/Sweden /Australia			(85)			

Main Findings Lean Healthcare Classification

	MAIN FINDINGS SCOPE					
COUNTRY	OUTCOMES	MEASURES	RISKS	BARRIERS	ENABLERS	SUSTAINABILIY
USA	(1)(3)(4)(5)(6)(9)(12)(12)(15)(19)(22)(24)(26)(27)(28)(30)	(10)(13)(20)(23)	(7)(17)(31)(32) (33)	(2)(11)(16)(21)	(8) (29)	(14) (25)
Canada	(34) (35) (36)					
UK	(37)(38)(42) (43)(44)(45) (47)(48)(57)(58)(60)(61)	(50) (54) (59)		(40) (46)(52)(53) (55)	(39) (56)	(41) (49) (51)
Netherlands	(62)					
Sweden	(63)(66) (67)(68)			(64)		(65)
Germany	(69)					
France	(70)					
Spain	(71)					
Italy	(72)					
Denmark				(73) (74)		
Australia	(75)(76)(77)				(78)	(79)
Sri Lanka	(80)					
Iran	(81)					
Brazil	(82)					
Portugal				(83)		
USA/Australia/Canada						(84)
Finland/Sweden /Australia	(85)					

CONCLUSION

In spite of the scarcity of cultural aspects in the Lean Healthcare literature, some patterns concerning the kind of publication and findings can be found. Future work would be necessary to go through deeper understanding of cultural issues behind success and failures in Lean deployment. Nevertheless some dimensions as Long-versus short Term orientation are visible in most of the articles confirming the previous theoretical considerations. Also, recent publications bring the organizational and national cultural issues related to barriers, enablers and sustainability factors in Lean deployment.

REFERENCES

Adler NJ, R Doktor and SG Redding (1986*)* "From the Atlantic to the Pacific Century: Cross-Cultural Management Reviewed." Journal of Management 12(2): 297–318.
Brandao de Souza L (2009) "Trends and approaches in Lean healthcare" in Leadership in Health Services Vol.22 (2) pp: 121-139.
Burgess N J and Z Radnor (2010) "Taxonomy of lean in healthcare: a framework for evaluating activity and impact" International Journal Of Health Care Quality Assurance (Under Review).
Dal Pont G (2010) "Contextual variables of Lean adoptions in services: an exploratory study" in Proceeding of 17th International Annual European Operations Management Association (EurOMA Conference- Managing Operations in Services Economies).
Doktor R H (1990) "Asian and American CEOs: A Comparative Study" Organizational Dynamics 18(3) pp: 46–56.
Drucker PF (1971) "Where can we learn from Japanese Management" Harvard Business Review, March-April. pp:110-122.
Drucker PF (1987) "Behind Japanese Success" Harvard Business Review,Jan-Febp:83-90.
Emiliani ML (2006) "Origins of lean management in America-The role of Connecticut businesses" Journal of Management History, 12(2) pp:176-184.
Farace D J (1998) "Foreword" In Third International Conference on Grey Literature. Jean Monnet Building, Luxembourg. 13–14 November 1997. Amsterdam: Grey Literature Network Service.
Fox WM (1977) "Japanese Management: Tradition under Strain" Business Horizons, August pp:76-85.
Goffee R and G Jones (2003) "The Character of a Corporation" 2nd ed. London: Profile Books LTD.
Hines P (2010) "How to create and sustain a Lean culture" Junewww.trainingjournal.com, pp 28-32.
Hines P and S Lethbridge (2008) "New development: Creating a Lean university" Public Money & Management Vol.28 (1) pp.53-56.
Hines P, A L Martins, and J Beale (2008) "Testing the Boundaries of Lean Supply Chain Thinking: observations from the legal sector" in Public Money & Management February 2008, pp: 35-40.
Hofstede G (1985) "The Interaction Between National and Organizational Value Systems" in Journal of Management Studies, 22 (4) pp:347-357.
Hofstede G (1994) "The Business of International Business is Culture" International Business Review 3(1) pp: 1–14.
Hofstede G (1998) "Identifying organizational subcultures: an empirical approach" Journal of Management Studies 35:1-12.
Hofstede G (2000) "Organizational culture: siren or sea cow? A reply to Dianne Lewis" Strategic Change, Mar-Apr, 9 pp:135-137.
Hofstede G (2003) "What is culture? A reply to Baskervile" in Accounting, Organizations and Society, 28, pp. 811-813.
Hofstede G (2004)"Business Goals and Corporate Governance" Asia PacificBusiness Review, Vol 10(3/4) pp:292-301.
Hofstede G and M Minkov (2010) "Long-versus short-term orientation: new perspectives" Asia Pacific Business Review, Vol 16 (4) pp: 493-504.
Holm M and P Ahlström (2010) "Lean Service – a literature review" in Proceeding of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.
Horvath D and C McMillan (1980) "Industrial Planning in Japan" California Management Review 23(1) pp:11-21.
Jones D T (2006) "Leaning healthcare, Management Services" Summer 2006; Vol 50 (2) pp:16-17.

Joosten T, I Bongers and R Janssen (2009) “Application of Lean thinking to health care: issues and observations” International Journal for Quality in Health Care, 21(5):341-347.
Liker JK (2004) “The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer” McGraw-Hill, New York.
Marengo FD (1979) “Learning from the Japanese: What or How” Management International Review 19 (4) p:39-46.
Mazzocato P, C Savage, M Brommels, H Aronsson and J Thor (2010) “Lean thinking in healthcare: a realist review of the literature” in Quality Safety in Health Care, 19 pp: 376-382.
McLaurin JR (2006) “Integration of National Cultures into Leadership: A Cross-Cultural Approach” Proceedings from the Academy for Studies in International Business 6(2):9-13.
McQuade D (2008) “New development: Leading Lean action to transform housing services” Public Money & Management Vol.28 (1) pp. 57-60.
Ohno T (1988) “The Toyota production system: beyond large scale-production” Productivity Press.
Ouchi WG and RI Johnson (1974) “Made in America Lunder Japaneses Management” Harvard Business Review, Set-Oct pp: 61-69.
Ouchi WG (1981) “Theory Z Corporations: Straddling U.S. and Japaneses Molds” Industry Week Vol 209 (3) pp: 48-54.
Oudenhoven J P (2001) “Do Organizations Reflect National Cultures? A 10-Nation Study.” International Journal of International Relations, 25 pp:89–107.
Poksinska B (2010) “The current state of Lean implementation in the health care: literature review” Quality Management Health Care, Oct-Dec, 19(4) pp: 319-329.
Radnor Z J and P Walley (2008) “Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector” Public Money & Management February pp: 13-20.
Schein E H (1992) “Organizational Culture and Leadership” 2nd ed San Francisco, Jossey-Bass, 15–20.
Schonberger RJ (2010) “How Toyota Lost Its Lean: Lessons on How to Make Lean Sustainable” in Proceedings of POMS 2010 Conference – Vancouver, B.C., May 8, Canada.
Scorsone EA (2008) “New development: What are the challenges in transferring Lean thinking to government?” Public Money & Management, Vol.28(1), pp. 61-64.
Sobek DK and M Lang (2010) “Lean Healthcare: Current State and Future Directions” Proceedings of the 2010 Industrial Engineering Research Conference, A. Johnson and J. Miller, editors.
Takeuchi H, E Osono and N Shimizu (2008) “The Contradictions that Drive Toyota’s Success” Harvard Business Review, June pp:96-104.
Thanopoulos J and J W Leonard (1996) “Nourishing American Business with Japanese Recipes” Review of Business Fall 18(1) pp:7-10.
Towill DR and M Christopher (2005) “An evolutionary approach to the architecture of effective healthcare delivery systems” Journal of Health Organisation and Management 19(2) pp: 130-1467.
Vogel, E G (1978) “Guided Free Enterprise in Japan” Harvard Business Review, May- Jun pp: 161-170.
Weiss A (1984) “Simple Trues of Japanese manufacturing” Harvard Business Review, pp: 119-125.
Winch S and AJ Henderson (2009) “Making cars and making health care: a critical review” Med J Aust, 191: 28-29.
Womack JP and DT Jones (1996)(2003) “Lean Thinking, Banish Waste and Create Wealth in Your Corporation”, London: Simon & Schuster.
Wong M (2010) “*Guanxi* Management in Lean Production System – An Empirical Study of Taiwan-Japanese Firms” American Journal of Economics And Sociology Vol.69(3) pp: 1079-1106.
Young TP and SI McClean (2008) “A critical look at Lean Thinking in healthcare” Quality and Safety in Health Care, 17: 382-386.

REFERENCES CLASSIFIED:

(1) Endsley S, MK Magill and MM Godfrey (2006) " Creating a Lean Practice" Family Practice Management, April, available at www.aafp.org/fpm

(2) Stolle R and D Parrott (2007) "It's Not Easy Being Lean, But Scripting Can Help" Health Management Technology 28(2) pp:40-42.

(3) Towne J (2006) " Going Lean Streamlines Processes, Empowers Staff and Enhances Care" Hospitals & Health Networks 80(10) pp: 34-35.

(4) Weber DO (2006) "Toyota-style Management Drives Virginia Mason" The Physician Executive 32(1) pp: 12-17.

(5) Kent A (2008) "Leaning Towards Efficiency" Health Management Technology 29(4) pp: 20-23.

(6) Bushell S, J Mobley and B Shelest (2002) "Discovering Lean Thinking at Progressive Healthcare" The Journal for Quality & Participation, Summer pp:20-25.

(7) Mazur LM and S G Chen (2009) "An empirical study for medication delivery improvement based on healthcare professional' perceptions of medication delivery system" Health Care Management Science 12 pp: 56-66.

(8) Bliss D (2009) "Lean in Healthcare – Wow" Frontiers of Health Services Management, Fall 26(1) pp: 39-42.

(9) Serrano L and F W Slunecka (2006) "Lean Processes Improve Patient Care" Healthacre Executive Nov/Dec 21(6) pp: 36-38.

(10) Grunden N (2009) "Lean at the Front Line: All Hands on Deck" Frontiers of Health Services Management 26(1) pp:33-37.

(11) Langabeer J R, J L DelliFraine, J Heineke and I Abbass (2009) "Implementation of Lean and Six Sigma quality initiatives in hospitals: A goal theoretic perspective" Operations Management Research Vol 2 pp: 13-27.

(12) Womack J, A Byrne, O Fiume, G Kaplan and J Toussaint (2005) "Going Lean in Healthcare" White Paper, Jan/Feb. Institute for Healthcare Improvement. Boston, MA.

(13) Rutledge J, M Xu and J Simpson (2010) "Application of the Toyota Production System Improves Core Laboratory Operations" American Journal of Clinical Pathology 133 pp: 24-31.

(14) Tonkin L and M Bremer (2009) "ThedaCare's Culture of Continuous Daily Improvements" 25(1) First Issue pp: 6-12 available at www.ame.org

(15) Melanson S, E Goonan, M Lobo, J Baum, J Paredes, K Santos, M Gustajson and M Tanasijevic (2009) "Applying Lean/Toyota Production System Principles to Improve Phlebotomy Patient Satisfaction and Workflow" American Journal of Clinical Pathology 132 pp: 914-919.

(16) Toussaint J (2009) "Why are we still underperforming?"Frontiers of Health Services Mangement 26(1) pp:27-32.

(17) Buesa RJ (2009) "Adapting lean to histology laboratories" Annals of Diagnostic Pathology 13 pp: 322-333.

(18) Kim C, D Spahlinger, J Kin and J Billi (2006) "Lean Health Care: What Can Hospitals Learn from a World-Class Automaker?" Society of Hospital Medicine Vol 1(3) pp: 191-199.

(19) Poole T and L Mazur (2010) "Assessing Readiness for Lean Change in Emergency Department" Proceedings of the 2010 Industrial Engineering Research Conference.

(20) Varkey P, K Reller and R Resar (2007) "Basics of Quality Improvement in Health Care" Mayo Clinic Proceedings, 82(6) pp: 735-739.

(21) Graban M (2007) "Lean in the laboratory" Lean Manufacturing, pp: 53-57.

(22) Kim C, J Hayman, J Billi, K Lash and T Lawrence (2007) "The Application of Lean Thinking to the Care of Patients With Bone and Brain Metastasis With Radiation Therapy" Journal of Oncology Practice 3(4) pp:189-193.

(23) Hassel A, C Glass, C Yip and P Eneff (2010)"The combined positive impact of Lean methodology and Ventana Symphony autostainer on histology lab workflow" BMC Clinical Pathology 10:2.

(24) Dickson E, S Singh, D Cheung, C Wyatt and A Nugent (2009) "Application of Lean Manufacturing Techniques in the Emergency Department" The Journal of Emergency Medicine 37(2) pp:177-182.

(25) Dickson E, Z anguelov, D Vetterick, A Eller and Sabi Singh(2009) "Use of Lean in the Emergency Department: A Case series of 4 Hospitals" Annals of Emergency Medicine 54(4) pp:504-510.
(26) Zarbo R, M Tuthill, R D'Angelo, R Varney and A Ormsby (2009) "Reduction of Surgical Pathology In-Proocess Misidentification Defects by Bar Code-Specified Work Process Standardization" American Journal of Clinical Pathology 131 pp:469-477.
(27) D'Angelo R and R Zarbo (2007) "Measures of Process Defects and Waste in Surgical Pathology as a Basis for Quality Improvement Initiatives" American Journal of Clinical Pathology128 pp: 423-429.
(28) Cankovic M, R Varney, L Whiteley, R Brown, R D'Angelo and R Zarbo (2009) "The Henry Ford Production System: Lean Process Redesign Improves Service In the Molecular diagnostic Laboratory"Journal of Molecular Diagnostics 11(5) p:390-398.
(29) Pate D and M Puffe (2007) "Improving Patient Flow" The Physician Executive May-Junpp:32-36.
(30) Lummus R, R Vokurka and B Rodeghiero (2006), "Improving Quality through Value Stream Mapping: A case study of a Physician's Clinic" Total Quality Management 17(8) pp:1063-1075.
(31) Furman C (2005) "Implementing a Patient Safety Alert System" Nursing Economics 23(1) pp:42-45.
(32) Mazur L and S Chen (2008) "Understanding and reducing the medication delivery waste via systems mapping and analysis" Health Care Management Science 11 pp:55-65.
(33) Raab S, D Grzybicki, D Sudilovsky, R Balassanian and C Vrbin (2006) " Effectiveness of Toyota Process redesign in Reducing Thyroid Gland Fine-Needle Aspiration Error" American Journal of Clinical Pathology 126 pp:585-592.
(34) Willoughby K , B Chan and M Strenger (2010) "Achieving wait time reduction in the emergency department" Leadership in Health Services 23(4) pp: 304-319.
(35) Panchek P (2005) "Lean Health Care? It Works!" Proceedings of AME International Canadian Regional Conference.
(36) Tanineez G (2005) "Pulling Lean through a Hospital" White Paper available at www.lean.org.
(37) Castro P, S Dorgan and B Richardson (2008) "A healthier health care system for the United Kingdom" available at mckinseyquarterly.com
(38) Burgess N, Z Radnor and R Davies (2009) " Taxonomy of Lean in Healthcare: A framework for evaluating activity and impact" Proceedinf of 2009 Euroma Conference, Sweden.
(39) Papadopoulos T, Z Radnor and Y Merali (2011) "The role of actor associations in understanding the implementation of Lean thinking in healthcare" International Journal of Operations & Production Management 31(2) pp:167-191.
(40) Brandão de Souza L and M Pidd (2011) " Exploring the barriers to lean health care implementation" Public Money & Management Jan pp:59-66.
(41) Papadopoulos T and Y Merali (2008) "Stakeholder Network Dynamics and Emergent Trajectories of Lean Implementation Projects: A Study in the UK National Health Service" Public Money & Management February pp:41-48.
(42) Lodge A and D Bamford (2008) "New Development: Using Lean Techniques to Reduce Radiology Waiting Times" Public Money & Management February pp:49-52.
(43) Heath g and J Radcliffe (2010) "Exploring the utility of current performance measures for changing roles and practices of ambulance paramedics" Public Money & Management May pp:151-158.
(44) Hoskins R (2010) "Is it time to "Lean" in emergency care?" International Emergency Nursing 18 pp: 57-58.
(45) Esain A, L Angel and K Robertson (2005) "Solutions for Problems: The NHS, Lean Thinking and Six Sigma" Cardiff Logistics & Operations Management Working Papers available at www.cardiff.ac.uk/carbs
(46) Radnor Z, M Holweg and J Waring (2011) "Lean in healthcare: The unfilled promise?" Social Science & Medicine pp:1-8, doi:10.1016/j.socscimed.2011.02.011
(47) Fillingham D (2007) "Can lean save lives?" Leadership in Health Services 20 (4) pp:231-241.

(48) Decker W and L Stead (2008) "Application of lean thinking in health care: a role in emergency departments globally" International Journal of Emergency Medicine Vol 1 pp:161-162.
(49) Esain A, S Williams and L Massey (2008) "Combining Planned and Emergent Change in a Healthcare Lean Transformation" Public Money & Management February pp:21-26.
(50) Young T and S McClean (2009) "Some challenges facing Lean Thinking in Healthcare" International Journal for Quality in Health Care 21(5) pp: 309-310.
(51) Radnor Z and M Holweg (2010) " From Tools to Systems: A critical appraisal of Lean Healthcare implementations" Proceedings of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.
(52) Waring J and S Bishop (2010) "Lean healthcare: Rhetoric, ritual and resistance" Social Science & Medicine 71 pp:1332-1340.
(53) Burgess N and Z Radnor (2010) "Lean paradox: can lean influence healthcare?" Proceedings of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.
(54) Grove AL, JO Meredith, M Macintyre, J Angelis and K Neailey (2010) "Lean implementation in primary care health visiting services in National Health Service UK" Quality Safety in Health Care 19 pp1-5.
(55) Parnaby J and D Towill (2008) "Seamless healthcare delivery systems" International Journal of Health Care Quality Assurance21(3) pp:249-273.
(56) Cooper R and C Mohabeersingh (2008) "Lean thinking in a healthcare system-innovative roles" Journal of Pre-Clinical and Clinical Research 2(2) pp:110-117.
(57) Walley P (2003) "Designing the accident and emergency systems: lessons from manufacturing" Emergency Medical Journal 290 pp:126-130.
(58) Radnor Z and P Walley (2008) "Learning to Walk Before we Try to Run: Adapting Lean for the Public Sector" Public Money & Management Feb p:13-20.
(59) Kullar P, F Harris, J Briggs, J Willis and P Axon (2009) "The use of Lean Thinking techniques in implementing the Department of Health, UK, 18-week waitinf time directive for cochlear implantation" Cochlear Implants International, DO: 10.1002/cii.418.
(60) Herring L (2009) "Lean experience in primary care" Quality in Primary Care 17 pp: 271-275.
(61) Lodge A and D Bamford (2007) "Health service improvement through diagnostic waiting list management" Leadership in Health Services 20(4) pp: 254-265.
(62) van Vliet EJ, W Sermeus, C van Gaalen, J Sol and J Vissers (2010) "Efficacy and efficiency of a lean cataract pathway: a comparative study" Quality Safety in Health Care pp 1- 6.
(63) Kollberg B and J Dahlgaard (2007) "Measuring lean initiatives in health care services: issues and findings" International Journal of Productivity and Performance Management 56(1) pp: 7-24.
(64) Jacobsson T and P Ahlström (2010) " Factors that hinder the implementation of process flow solutions in healthcare, Empirical findings from four emergency departments" Proceedings of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.
(65) Mazzocato P, H Aronsson and J Thor (2010) " Towards better operations in a Swedish paediatrics accident and emergency department" Proceedings of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.
(66) Lindskog C and F Nilsson (2010) "outcome of Lean in Swedish healthcare – rationalization or increased patient value?" Proccedings od POMS 21st Annual Conference, Vancouver, Canada.
(67) Setijono D, A M Naraghi and U P Ravipati (2010) "Decision support system and the adoption of lean in a Swedish emergency ward" International Journal of Lean Six Sigma 1(3) pp: 234-248.

(68) Trägardh B and K Lindberg (2004) "Curing a meagre health care system by lean methods – translating "chains of care" in the Swedish health care sector" International Journal of Health Planning and Management 19 pp:383-398.
(69) Sharma V, J Abel, M Al-Hussein, K Lennerts and U Pfründer (2007) " Simulation application for resource allocation in facility management processes in hospitals" Facilities 25(13/14) pp: 493-506.
(70) Ballé M and A Régnier (2007) "Lean as a learning system in a hospital ward" Leadership in Health Services 20(1) pp: 33-41.
(71) Correa F A, MJA Gil and LB Redín (2005) "Benefits of Connecting RFID and Lean Principles in Healthcare" Working Paper 05-44 Business Economics Series 10, July, Universidad Carlos III de Madrid.
(72) Portioli-Staudacher A (2008) "Lean Healthcare- An Experience in Italy" in IFIP International Federation for Information Processing, Vol 257, Lean Business Systems and Beyond, Tomasz Koch, ed pp: 485-492.
(73) Nielsen A P and K Edwads (2010) "Implementing lean in healthcare: Barriers and opportunities" Proceedings of 17th International Annual European Operations Management Association (EurOMA).
(74) Laursen M L, F Gertsen and J Johansen (2003) "Applying Lean Thinking in Hospitals-Exploring Implementation Difficulties" Working Paper, Center for Industrial Production, Aalborg University, Denmark.
(75) Ben-Tovim D, J Bassham, D Bennett, M Dougherty, M Martin, S O'Neill, J Sincock and M Szwarcbord (2008) " Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking" MJA vol 188(6) March, pp: S27-S31.
(76) Ben-Tovim D, J Bassham, D Bolch, M Martin et l (2007) "Lean thinking across a hospital: redesigning care at the Flinders Medical Centre" Australian Health Review Feb 31(1) p:10-15.
(77) King D, D Ben-Tovim, and J Bassham (2006) "Redesigning emergency department patient flows: Application of Lean Thinking to health care" Emergency Medicine Australasia 18 pp: 391-397.
(78) Ben-Tovim D, M Dougherty, T O'Connell and K McGrath (2008) "Patient journeys: the process of clinical redesign" MJA vol 188(6) pp: S14-S17.
(79) McGrath K, D Bennett, D Bem.Tovim, S Boyages, N Lyons and T O'Connell (2008) "Implementing and sustaining transformational change in health care: lessons learnt about clinical process redesign" MJA vol 188(6) pp: S32-S35.
(80) Withanachchi N, Y Handa, KK Karandagoda, PP Pathirage, NC Tennakoon and DS Pullaperuma (2007) " TQM emphasizing 5-S principles" International Journal of Public Sector Management 20(3) pp: 168-177.
(81) Rahimnia F and M Moghadasian (2010) "Supply chain leagility in professional services: how to apply decoupling point concept in healthcare delivery system" Supply Chain Management: An International Journal 15(1) pp: 80-91.
(82) Araujo C, K Figueiredo and A Silberstein (2008) "Principios Enxutos Aplicados rem Serviços de Saúde: Cinco Casos Brasileiros" Proceedings of SEGet – Simoósio de Excelência em Gestão e Tecnologia.
(83) Sousa P, AS Uva, F Serranheira, F Pinto, J ovretveit, N Klazinga, R Suñol and D Terris (2009) "The patient safety journey in Portugal: challenges and opportunities from a public health perspective" Revista Portuguesa de Saúde Pública, número especial-25 anos pp: 91-106.
(84) Holden RJ (2010) "Lean Thinking in Emergency Departments: A Critical Review", annals of Emergency Medicine Vo 20 (10) pp:1-14.
(85) Meredith J, F Young, P Walley and M Macintyre () "A multi centred comparison of patient changeovers in orthopaedic theatres and recommendations for efficiency improvements using a lean analysis" Proceedings of 17th International Annual European Operations Management Association (EurOMA) Conference- Managing Operations in Services Economies.

INTEGRATING THE SUPPLY CHAIN - THE IMPACT OF ATTITUDES, PATTERNS AND PRACTICES ON SUPPLY CHAIN PERFORMANCE

Dr. Inga-Lena Darkow*
Research Director

Heiko Wöhner
External Doctoral Student

Prof. Dr. Gernot Kaiser
Assistant Professor

EBS Business School (EBS), Wiesbaden, Germany
Supply Chain Management Institute (SMI)

Research Paper

Introduction

The economic crisis has demonstrated that highly integrated supply chains are as strong as their weakest link. Therefore, one of the key topics in supply chain research has recently been how companies integrate externally with customers, to adapt to changing demands, and with suppliers, to ensure efficient and highly responsive material supply. Research on supply chain integration (SCI) has focused on customer and supplier integration as well as on internal, or intra-organizational, integration which improves the interfaces among corporate functions. However, research on the contribution of supply chain integration to performance has shown inconsistent results. We attribute this to incomplete perspectives of SCI, in particular the tendency to focus on attitude, patterns or practices only. This study extends the developing body of literature on SCI by surveying attitudes, patterns and practices in supply chain integration and their impact on supply chain performance.

There is an underlying assumption in supply chain integration research that a high level of integration leads to better corporate performance (Lee et al. 2008, p. 3; Stank et al. 2001, p. 32; van der Vaart and van Donk 2008, p. 52). Nevertheless, the identification of relevant elements for integration and their impact on supply chain performance is still lacking theoretically-based and empirically-tested consensus (van der Vaart and van Donk, 2008). Van der Vaart and van Donk (2008) investigated this issue by conducting a literature review and content analysis of articles on survey-based research in supply chain integration. By incorporating the different fields of supply chain integration research, they propose a model with three different perspectives of supply chain integration and their impact on performance. These perspectives are practices, patterns, and attitudes. Practices are tangible activities or technologies relevant for collaboration between two supply chain partners; patterns describe the interactions between these partners; and attitudes are the behaviours of supply chain partners to each other or supply chain management (van der Vaart and van Donk 2008). The integration model has not yet been operationalised for empirical testing.

Most importantly, the question remains which elements of supply chain integration these perspectives refer to. Such fields are competencies, composed of underlying capabilities, which are critical for supply chain performance (Rodrigues et al. 2004; Bowersox et. al. 1999; Stank et al. 2001; Closs and Mollenkopf 2004). The identification of relevant competencies and capabilities and their impact on supply chain performance supports decision making for supply chain design, supply chain optimisation and supply partner management in practice. We attempt to close the gap between research about supply

* To correspond to: Inga-Lena.Darkow@ebs.edu

chain integration and supply chain competencies by answering the following research question: Which competencies and capabilities are required for supply chain integration in order to increase supply chain performance?

Corresponding to our research questions, the remainder of this paper is structured as follows: First, we motivate selecting the integration model of van der Vaart and van Donk as a research basis. The key elements of supply chain integration – here integration perspectives – are introduced. The Bowersox et al. framework is presented. Second, we investigate whether the Bowersox et al. framework's competencies and capabilities are compatible with the integration model. Third, the results of a content analysis are presented in which we investigate the actuality of the reference framework. The resulting supply chain integration framework covers competencies and capabilities with their different perspectives attitudes, patterns and practices. Finally, the main findings are summarised and further research opportunities are highlighted.

Theoretical Background

The thorough analysis and recapitulation of existing elements and frameworks is a prerequisite for developing new frameworks (Wang et al. 2005). Many frameworks on supply chain management were published recently (e.g. Tan 2001 and Croom et al. 2000 on supply chain management literature). A reason for the multitude of different frameworks is given by Chen and Paulraj (2004) who propose that this is due to different approaches to measure supply chain performance. Van der Vaart and van Donk (2008) thoroughly analysed supply chain integration literature and discussed frameworks related to supply chain performance. Therefore, our approach to identify and structure competencies and capabilities for supply chain integration is based on their considerations.

Integration model of van der Vaart and van Donk (2008)

Van der Vaart and van Donk (2008) evaluated ten major academic journals for logistics, operations, and supply chain management research (van der Vaart and van Donk 2008). Based on a review of relevant articles addressing supply chain integration, they conclude that supply chain integration research has several shortcomings: First, the often assumed positive relation between the level of integration and the performance depends on the particular research approach. Second, a high degree of integration is only favourable under particular business conditions. Third, the amount of partners investigated varies across studies: Some studies consider complete supply chains while others investigate specific buyer-supplier-relationships or interactions. Additionally, integration is operationalised differently in survey research. Summarising their critical review of current supply chain integration research, van der Vaart and van Donk developed their own integration model.

In their integration model they differentiate among three integration perspectives: supply chain attitudes, patterns, and practices are distinctive but at the same time interrelated perspectives of supply chain integration. The attitude to supply chain integration depends on the power distribution in a buyer-supplier-relationship. Attitudes include the expectations about the relationship, the view of the supply chain, and the values that exist for co-operation (van der Vaart and van Donk 2008). Although research often investigates attitudes, it remains unclear whether these attitudes lead to certain actions. Therefore, supply chain patterns and supply chain practices need to be considered as well. Practices are "tangible activities or technologies that play an important role in the collaboration of a focal firm with its suppliers and/or customers" (van der Vaart and van Donk 2008, p. 47). The integration of information systems through interfaces and the synchronisation of processes are just two examples. Supply chain patterns encompass the "interaction patterns, between the focal firm and its suppliers and/or customers" (van der Vaart and van Donk 2008, p. 47). These interaction patterns refer to personal communication between members of the organisation as well as formal, periodical interactions (Figure 1).

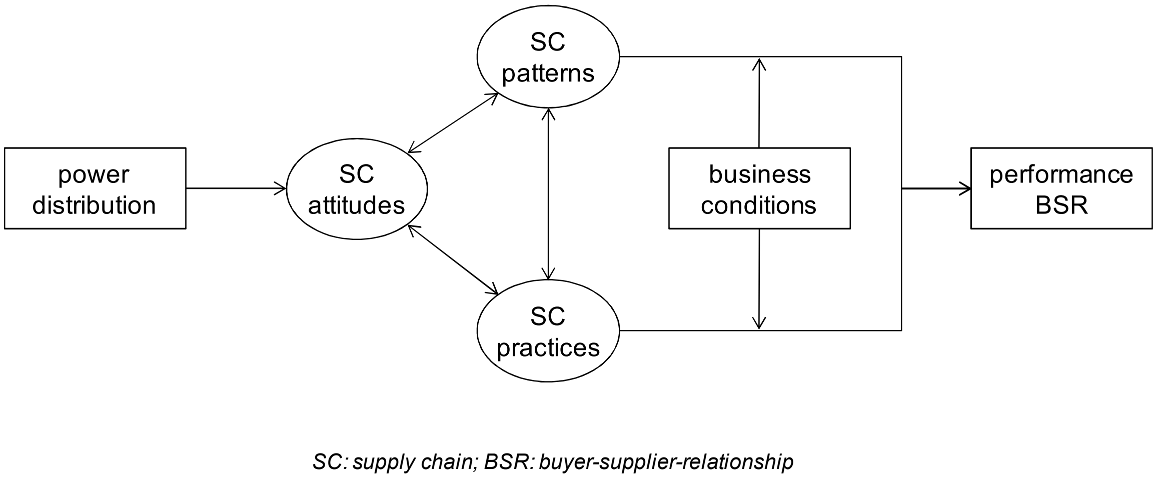


Figure 1: Proposed research model, integration model
(modified, van der Vaart and van Donk 2008, p. 51 and 53)

Van der Vaart and van Donk propose further testing of their model to analyse: first, the impact of power distribution on the three different integration perspectives, second the impact of these perspectives on supply chain performance, and third the influence of business conditions. For this purpose, the model needs to be operationalised. Most importantly, attitudes, patterns, and practices need to cover all essential elements of the supply chain. Supply chain research provides these elements for operationalisation, such as competencies and capabilities, which are critical for supply chain performance.

The Bowersox et al. framework (1999)
Among others, the Bowersox et al. framework (Bowersox et al. 1999) is a well-accepted framework of supply chain competencies and capabilities (Campbell and Sankaran 2005). The framework was developed in a multi-method approach, which combined a theoretical literature review, case studies for development and validation, as well as a research generalisation through an expert survey (Bowersox et al. 1999). It was tested and confirmed in several studies in different international markets between 1999 and 2002 (Mollenkopf and Daipiran 1999; Closs and Mollenkopf 2004; Carranza et al. 2002; Morash and Lynch 2002). This framework might provide a sound basis for operationalisation of the integration model since it is composed of relevant competencies and capabilities. Thus, it is briefly presented in the following discussion.

The Bowersox et al. framework encompasses the range and continuity required to link the resource base to end-customers. The framework includes in an operational context traditional processes related to procurement, production and logistics, facilitating order fulfilment and replenishment across the supply chain. Integration is essential internally as well as with customers and suppliers. There are three competencies in this context: customer integration, internal integration, and (material and service) supplier integration. Related to a planning and control context the framework incorporates information technology and measurement systems to facilitate planning and control of integrated operations with the two competencies: technology and planning integration and measurement integration. Successful implementation of supply chain strategy will depend on the quality of the basic business relationship between partners and is represented in the behavioural context with the required competence relationship integration.

Structure for Operationalisation
Prior to operationalising the integration model, competencies relevant for supply chain integration need to be selected and structured. The Bowersox et al. framework provides a sound structure for competencies and underlying capabilities, and their impact on

supply chain performance. Competencies are viewed as constructs, and capabilities are the related items (Stank et al. 2001). With respect to the criticism regarding previous research (van der Vaart and van Donk 2008) each capability needs to incorporate all three integration perspectives. Consequently, the usability of the Bowersox et al. framework for operationalisation of the integration model is analysed.

First, we investigated for all capabilities if they cover the perspectives attitude, pattern, and practice. For this reason we analysed the questions for each capability of the Bowersox et al. framework. Consequently, we allocated each question to one of the three perspectives.

The results demonstrate that the competencies customer integration, supplier integration and relationship integration cover all three perspectives (attitude, pattern, and practice) on supply chain integration, but only six capabilities within these competencies include all three perspectives. In order to investigate supply chain integration with a sound research approach, attitudes, patterns, and practices need to be equally present to all capabilities. Although not balanced, the Bowersox et al. framework investigates all three perspectives and is a solid foundation for operationalisation. However, since the perspectives are not equally distributed, the capabilities and related questions need to be carefully enhanced. Favourably, a slight modification of the questions was used to investigate a certain perspective. The re-wording of the relevant questions was performed by the authors. However, in some cases, it was necessary to substitute questions. This procedure was applied with respect to the theoretical background and description of each capability in Bowersox et al. (1999). The resulting questionnaire has equally distributed integration perspectives for all supply chain capabilities, i.e. there is one question referring to attitudes, one referring to patterns and one referring to practices in each capability. As a consequence, the updated framework operationalises attitudes, patterns, and practises in balance.

State-of-the-art Operationalisation

The Bowersox et al. framework was developed ten years ago. Therefore, the competencies in the Bowersox et al. framework may have to be adapted to current supply chain competencies. This step is imperative to apply it to the integration model.

In 1999, the Bowersox team identified and proved that six competencies contribute to supply chain performance (Bowersox et al., 1999). To evaluate whether all six competencies are still relevant in current supply chain research, a literature review and a content analysis were conducted. There is evidence that those competencies relevant for supply chain performance are also required for improving supply chain integration. Therefore, articles with the term "supply chain performance" in the abstract or title were searched for in ten journals that qualified as a reasonable set in earlier supply chain research (van der Vaart and van Donk 2008). This approach did not limit the search results to factors that were identified earlier in supply chain integration research and thus included in the research of van der Vaart and van Donk (2008). Moreover, a set of elements from various fields of supply chain research was generated.

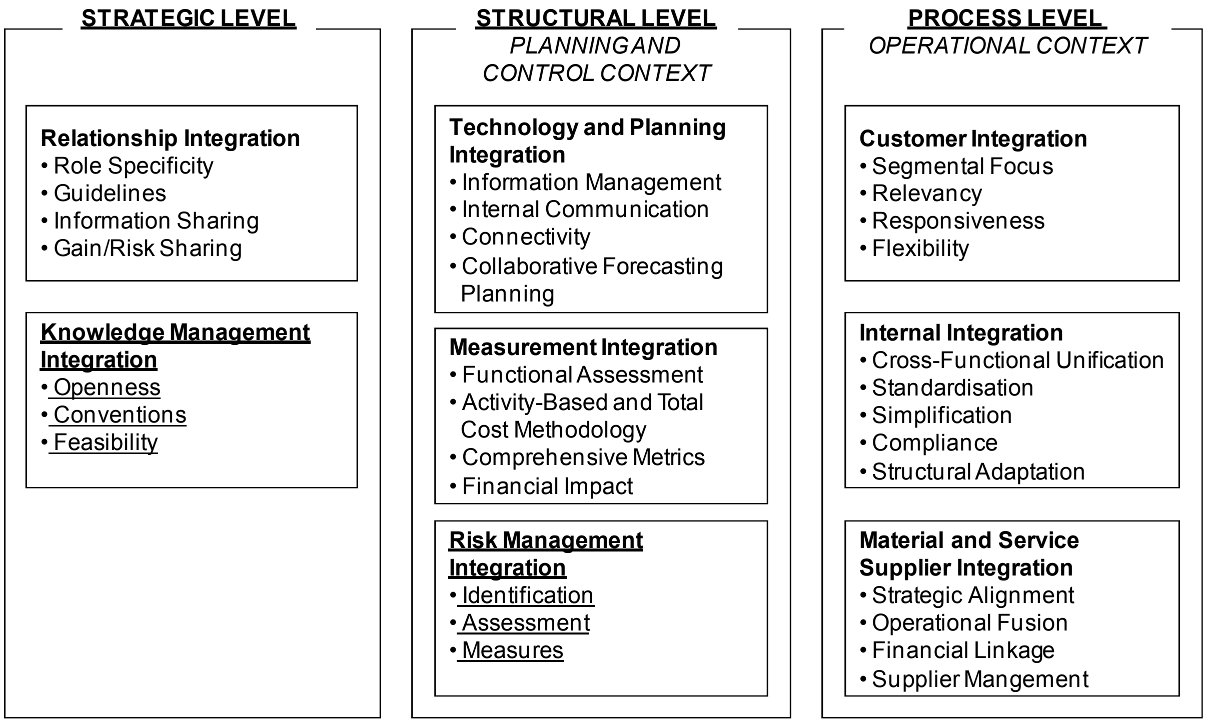
In total, 75 records were found. Five search results were not original articles but book reviews or summaries of other articles' abstracts. Therefore, they were excluded from further analysis. Articles based on Operations Research as a methodological approach were excluded from further analysis (van der Vaart and van Donk, 2008, p. 43) for the following three reasons: First, these articles use terminology differently than in empirical and conceptual research. Second, the methodology to develop frameworks, in terms of mathematical expressions, fundamentally differs from the derivation of the Bowersox et al. framework. Third, the models vary between different Operations Research projects, making it even more difficult to compare results. An additional analysis in the Journal "Production Planning and Control" produced 13 articles with the key word "supply chain performance", but non of them qualified for the sample due to their focus on Operations

Research or qualititative empirical research. Thus, an additional 33 articles were excluded from the analysis. A total of 37 articles qualified for the content analysis.

Next, coding was performed in order to identify factors that are related to supply chain performance. Since the coding procedure requires capturing the performance-related content of the articles, the entire document, i.e. title, abstract and keywords, was chosen as a unit of analysis for this research. If available, keywords provided by the articles' authors were used. The codes of the 37 articles were grouped according to the competencies and capabilities of the Bowersox et al. framework. The original definitions of the competencies and capabilities (Bowersox et al., 1999) were consulted during this process and abstracts or articles were reread whenever the context of the codes was ambiguous.

Between six and 19 articles could be grouped to each competency. This finding indicates that all competencies of the Bowersox et al. framework are subject to current research on supply chain performance. However, four codes could not be allocated within the existing competencies; this indicates that the related articles cover fields that are not yet included within the framework. Although these articles account for only 11% of the selected articles, more evidence exists that knowledge management and risk management are of growing importance for supply chains (Harland et al. 2003; Zsidisin et al. 2005; Tang, 2006; Kumar and Thondikulam 2005/2006; Peterson 2002). Knowledge management and risk management might contribute to a holistic operationalisation since they have the ability to potentially impact supply chain performance. Therefore, these two competencies shall be added to the existing six competencies of the Bowersox et al. framework. Capabilities for knowledge management and risk management were derived through a literature review in these fields and the two new competencies were integrated into the framework. The resulting, in its original form well-accepted, internationally-tested and adapted framework will be used to operationalise the integration model.

The Bowersox et al. framework comprises strategic, structural, and process dimensions and derives their influence on performance (Rodrigues 2004). Therefore and with respect to the strategic importance of knowledge management integration, the complete overview of capabilities is presented in Figure 2.



Changes to original framework are underlined

Figure 2: Modified Competencies and Capabilities

Influencing and Resulting Factors of Supply Chain Integration

In addition to the integration perspectives which can be operationalised by the modified competencies and capabilities, the integration model encompasses influencing and resulting factors (Figure 1). Power distribution impacts on the attitudes. Business conditions are a moderating factor for the impact of patterns and practices on performance which is a multi-dimensional construct. For investigating which competencies and capabilities of the supply chain are required for supply chain integration, it is necessary to build sound constructs for the influencing factors "power distribution" and "business conditions" as well as the resulting "performance". Therefore, this section provides a brief overview on items for those factors' measurement.

As called for by van der Vaart and van Donk (2008), power distribution amongst the supply chain members can be assumed to influence the level of supply chain integration. Recently, Zhao et al. (2008) investigated the influence of power on the integration between manufacturers and customers. While their research findings are limited to the Chinese industry, they provide a classification of inter-firm power based on Brown et al. (1995) and transfer the marketing and retail-oriented constructs (see also El-Ansary and Stern 1972) to the field of supply chain management, in the absence of multiple studies in this field (Zhao et al. 2008). Power distribution in supply chains depends on the supply chain members' use of mediated and non-mediated power, as well as on the symmetry of power distribution among the organisations (Brown et al. 1995). Mediated forms of power (i.e. reward, coercive) refer to particular actions of the more powerful organisation. Non-mediated forms of power (expert, referent, legitimate) function without the ability of the powerful organisation to control the reinforcement of a certain behaviour (Tedeschi et al. 1972; Johnson et al. 1993). It needs to be critically considered whether the demand or the supply side of the supply chain has a more powerful position (e.g. Brown et al. 1995; Zhao et al. 2008). Reward and coercive power are likely to be controlled by the customer through the placement or cancellation of orders. However, a supplier might have expert and referent power (e.g. through unique knowledge and reputation for important components and technologies which influence the buying behaviour of the final customer) and to some extent, legitimate power, if the supply chain is of collaborative nature. Likewise the power symmetry (respectively asymmetry) is not only characteristic for the relationships but can be supposed to influence the level of supply chain integration (Brown et al. 1995).

According to van der Vaart and van Donk and related research, business conditions "influence the internal and external processes of order processing, production planning, and scheduling [and] include logistical and competitive factors, demand characteristics, and manufacturing technologies" (Welker et al. 2008, p. 708). Thus, business conditions include delivery time, order winners, a variety of demand and supply chain relationship types, product and process characteristics, and the position of customer order decoupling point (Welker et al. 2008). It is important to take notice of the related research focuses on operations management, and information and communication technology. Within a broader supply chain integration context, in addition to process and product characteristics, the external environment of the supply chain might be included in the assessment of business conditions. Uncertainty was found to be an important factor for business conditions (Childerhouse and Towill 2002) and is reflected in the market and the political, economical, and sociocultural environment (Hollensen 2004). Items assessing business conditions consider, for instance, the concentration of an industry, the uniqueness of supplier's products, and the cost of switching to substitutes (Porter 1980; Hollensen 2004).

A multi-dimensional construct of performance was derived by Bowersox et al. to measure supply chain performance (Bowersox et al. 1999). It covers the assessment of financial and non-financial indicators concerning customer service, cost management, quality, productivity, and asset management. Although not in the focus of the methodological approach presented above, it was cross-checked during the evaluation of the research topics, if the construct is still up-to-date. For instance, quality, as an important factor for supply chains, was assessed by several articles. However, an additional or superfluous field of performance assessment could not be identified. Therefore and with respect to comparability with earlier studies, the assessment of performance shall be conducted, as in the Bowersox et al. framework.

Conclusions, Limitations and Further Research Opportunities

This study builds on previous works using a critical approach, and attempts to understand how management conceptualized competencies and perspectives on supply chain integration. We develop a supply chain integration model of competencies and perspectives. A content analysis of ten academic journals proved that the competencies and capabilities in the Bowersox et al. framework are still state-of-the-art. However, there is some evidence that the integration of knowledge management and risk management also contributes to supply chain performance. Therefore, these competencies were integrated into the Bowersox et al. framework and the capabilities were derived from a literature review in these fields. The modified framework provides a sound structure for investigating supply chain integration. Thus, it was utilised for operationalisation of the supply chain integration perspectives in the integration model. The resulting supply chain integration framework encompasses the operationalisation of the perspectives.

Second, the study confirms that two additional competencies are relevant to manage integration in supply chains: risk management and knowledge management. Two additional competencies and six related capabilities were added to incorporate contemporary research in these fields. Thus, the established framework is enhanced in order to reflect current developments in supply chain practice. The equal distribution regarding integration perspectives contributes to high quality empirical research with the modified framework. Third, the model includes three perspectives of integration: willingness (attitude), ability to (patterns), and implementation of (practices) supply chain integration, as recommended by van der Vaart and von Donk (2008). In addition to advancing the supply chain integration research of van der Vaart and van Donk (2008) towards empirical testing, this article also contributes to theory development in the field of supply chains. The Bowersox et al. framework was modified after performing content analysis. In addition to this advancement, a contribution to theory development was performed by combining two different streams of supply chain research: Linking supply chain integration and supply chain competencies to one another – with the theoretical background of each field – advances the understanding of both fields. It also allows future research to benefit from findings in the other field. On the one hand, in order to investigate the interactions among attitudes, patterns, and practices, as well as the impact of business conditions on the optimal level of supply chain integration, the underlying constructs have to be understood, i.e. the supply chain competencies. On the other hand, research on supply chain competencies needs to take the different perspectives during formulation and empirical testing of its constructs into account, as well as interactions among them.

However, our research also has limitations. The presented operationalisation of the supply chain integration framework has not been empirically tested. Although there is evidence that the modifications in the questionnaire, based on the findings of van der Vaart and van Donk (2008), contribute to improve the questionnaire, the assumptions have yet to be proven. Likewise, the integration of knowledge management and risk management relies on a rather small number of articles within the selected sample. Despite increasing awareness on these competencies, their integration along the supply chain might not impact supply chain performance. We chose to integrate them as separate competencies. If they are found to be superfluous in the supply chain integration framework, one or even both new competencies might need to be removed.
Thus, the supply chain integration framework provides various research opportunities. Empirical research can be performed to investigate the path from power distribution to integration and supply chain performance. Interactions between the perspectives of integration can be assessed and the influence of business conditions can be evaluated. Additionally, the contribution of integrating knowledge management and risk management might be considered.

References

Bowersox, D. J., Closs, D. J., Stank, T. P., 1999. 21st Century Logistics: Making Supply Chain Integration a Reality. Oak Brook IL: Council of Logistics Management (CLM).
Brown, J. R., Lusch R. F., Nicholson, C. Y., 1995. Power and Relationship Commitment: Their Impact on Marketing Channel Member Performance. Journal of Retailing, 71 (4), 363-392.
Campbell, J., Sankaran, J., 2005. An inductive framework for enhancing supply chain integration. International Journal of Production Research, 43 (16), 3321-3351.
Carranza, O., Maltz, A., Antun, J. P., 2002. Linking logistics to strategy in Argentina. International Journal of Physical Distribution & Logistics Management, 32 (6), 480-496.
Chen, I., Paulraj, A., 2004. Towards a theory of supply chain management: the constructs and measurements. Journal of Operations Management, 22 (2), 119-150.
Childerhouse, P., Towill, D.R., 2002. Analysis of the factors affecting real-world value stream performance. International Journal of Production Research, 40 (15), 3499–3518.
Closs, D. J., Mollenkopf, D. A., 2004. A global supply chain framework. Industrial Marketing Management, 33, 37-44.
Croom, S., Romano, P., Giannakis, M., 2000. Supply chain management: an analytic framework for critical literature review. European Journal of Purchasing & Supply Management, 6, 67-83.
El-Ansary, A. I., Stern, L. W., 1972. Power Measurement in the Distribution Channel. Journal of Marketing Research, 9, 47-52.
Harland, C., Brenchley, R, Walker, H., 2003. Risk in supply networks. Journal of Purchasing and Supply Management, 9, 51-62.
Hollensen, S., 2004. Global Marketing, a decision-oriented approach. Prentice Hall, 3rd

edition.
Johnson, J, L., Sakano, T., Cote, J. A., Onzo, N., 1993. The Exercise of Interfirm Power and Its Repercussions in U.S. - Japanese Channel Relationships. Journal of Marketing, 57, 1-10.
Lee, C. W., Kwon, I.-W. G., Joo, S.-J., 2008. Supply Chain Integration and its Impact on Performance: A Structura Equation Model Approach. North American Research/Teaching Symposium.
Mollenkopf, D.A., Daipiran, G. P., 1999. World class logistics: How well do Australian/New Zealand firms perform?. Council of Logistics Management Annual Conference, Toronto, Canada.
Morash, E. A., Lynch, D. F., 2002. Public Policy and global supply chain capabilities and performance: A resource-based view. Journal of International Marketing, 10 (1), 25-51.
Peterson, H. C., 2002. The "Learning" Supply Chain: Pipeline or Pipedream?. American Journal of Aricultural Economics, 84 (5), 1329-1336.
Porter, M. E., 1980. Competitive Strategy. New York: The Free Press.
Rodrigues, A. M., Stank, T. P., Lynch, D. F., 2004. Linking Strategy, Structure, Process, and Performance in Integrated Logistics. Journal of Business Logistics, 25 (2), 65-94.
Stank, T. P., Keller, S. B., Closs, D. J., 2001-2002. Performance benefits of Supply Chain Logistical Integration. Transportational Journal, 41 (2/3), 32-46.
Tan, K.C., 2001. A framework of supply chain management literature. European Journal of Purchasing & Supply Management, 7, 39-48.
Tang, C. S., 2006. Perspectives in supply chain risk management. International Journal of Production Economics, 103, 451-488.
Tedeschi, J.T., Schlenker, B.R., Lindskold, S., 1972. The Exercise of Power and Influence: The Source of Influence. The Social Influence Process. Chicago: Aldine-Atherton, 287-375.
Van der Vaart, T., van Donk, D. P., 2008. A critical review of survey-based research in supply chain integration. International Journal of Production Economics, 111, 42-55.
Wang, Y. C. W., Heng, M .S. H., Ho, C. T. B., 2005. Business-to-business integration – the mediating effects of network structure and network atmosphere. Production Planning and Control, 16 (6), 575-585
Welker, G. A., van der Vaart, T., van Donk, D. P., 2008. The influence of business conditions on supply chain information-sharing mechanisms: A study among supply chain links of SMEs. International Journal of Production Economics, 113, 706-720.
Zhao, X., Huo, B., Flynn, B. B., Yeung, J. H. Y., 2008. The impact of power and relationship commitment on the integration between manufacturers and customers in a supply chain. Journal of Operations Management, 26, 368-388.
Zsidisin, G. A., Ragatz, G. L., Melnyk, S. A., 2005. The Dark Side of Supply Chain Management. Supply Chain Management Review, March, 46-52.

STRUCTURAL AND AGENTIC ANALYSIS OF SUPPLY-CHAINS: A SOCIAL NETWORK ANALYSIS APPROACH

Alan Sloane and Seamus O'Reilly (corresponding author),
University College Cork, Cork, Ireland

ABSTRACT

This research adds to a body of work exploring the role of Social Network Analysis (SNA) in the study of both relational and structural characteristics of supply chain networks. Two contrasting network cases (food enterprises and digital-based enterprises) are chosen in order to elicit structural differences in business networks subject to divergences in local embeddedness and the relative materiality of the goods and services produced. Our analysis and findings draw out differences in network structure – evidenced by metrics of network centralization and cohesion, the presence of components and other sub-groupings, and the position of central actors. We relate these structural features both to the nature of the networks and to the (qualitative) experiences of the actors themselves. We find, in particular, the role of customers as co-creators of knowledge (for the Food network), the central role of infrastructure and services (for the Digital network), the importance of ICT as a source of codified knowledge inputs, along with the continuing importance of geographical proximity for the development and transfer of tacit knowledge and for incremental learning.

Introduction:

Over recent decades fundamental political change has created the conditions to support a 'globalisation era' with far reaching consequences. In tandem rapid advances in Information and Communication Technology (ICT) has created a new set of 'technological separabilities'. Such 'separability' has prompted much discussion around notions such as the "death of distance" and the "end of geography" (Castells, 1996; Sassen, 2001; Graham, 1998) and thus the role of forces of agglomeration and dispersal. It also engages with debates on policy and practice, for example redefining "footloose industries" and FDI-led economic growth.

Within the past few years there has been a growing interest in bringing the techniques and perspectives of Social Network Analysis (SNA) to bear on the study of Supply-Chains (Kim et al. 2011; Sloane & O'Reilly 2010; Borgatti & Li 2009; Choi & Wu 2009; Choi & Kim 2008). While Social Network Analysis has become widely-accepted in research, and even quite widely adopted in policy studies, most work to date has concentrated on one network, or less frequently on multiplex networks – a set of distinct relations on the same set of actors. Comparison across networks of distinct actors in terms of network structure is a relatively new and active area of research e.g. (Entwisle et al. 2007; K. Faust forthcoming). This research paper describes the application of SNA to two contrasting network cases chosen in order to elicit structural differences in business networks subject to divergences in local embeddedness and the relative materiality of the goods and services produced.

The paper builds on previous work (Sloane and O'Reilly, 2010) that adopted a SNA approach. This previous work found that a mixed methods approach that includes SNA facilitates greater insight into social processes of both structure and agency ((Kelle 2001): making clear, for example, that relations are conceptual and cognitive entities; that actors actively construct the network; that the network serves as a resource to actors; and conversely that their actions are shaped by the structure of the network. The earlier work focused on a network with strong local embeddedness and thus largely ignored the increasing importance of global interactions along supply networks. This paper considers two networks that ex-ante might be considered a sharp contrast between local and global orientation. The paper begins with a brief overview of the context and methodology as we devote most the paper to illustration and discussion of our comparative work. We conclude with some observations regarding the impact of social embeddedness and the role of networks relations and structure in knowledge creation and dissemination.

Background and Methodology:

The objective of this paper is to investigate the insight that various SNA techniques may offer into the relational and structural nature of two contrasting networks - a network of food enterprises and a network of digitally-based enterprises. The former network was presented in Sloane and O'Reilly (2010) which also provides an overview of the SNA research design and describes the methodology adopted. In this paper we provide some context for the comparative study and a brief overview of the methodology.

In the mid to late 1990's there was a surge of speculation and futuristic prediction on the likely consequences of society's adoption of new technologies of computing and communication, fuelled particularly by emergent popular awareness of the "world-wide web". More specifically, journalists, government policy analysts and academic researchers proposed, with varying degrees of certitude, that the new age would bring about a "death of distance" (Cairncross 1998) or the "end of geography" (O'Brien 1992). The "digital revolution" would even "reshape the landscape" (Kotkin 2000).

In this new era the established locational constraints on economic activity, whether in terms of production tied to local resources and tradition, or on labour tied to the location of production or the location of consumption (in the case of services), were supposed to be weakened and possibly entirely removed. E-commerce, e-services, e-government were the bywords of the "information age". Much of the initial enthusiasm has been tempered in the succeeding years, and an awareness has developed that the interactions of the social, the spatial and the technological (not to mention the economic and the political) are "multi-layered, interrelated and complex" (Collins 2007).

These developments have rekindled interest in economic and social processes underlying the processes of agglomeration and dispersal, within the context both of Marshall's original insights and those of modern scholars, including those in the "Italian School" (Becattini et al 1990), the "California School" (Scott 1993, Saxenian 1994), "GREMI" (Aydalot and Keeble 1988) and in Scandinavia (Lundvall & Johnson 1994, Maskell and Malmberg 1999). These studies have pointed out the central structuring role played by knowledge, innovation and the development of competitive advantage. Thus this paper considers the types of knowledge; how knowledge is elaborated and communicated; and the role of spatial or social proximity in these processes. We characterise the nature of these two networks along two conceptual axes: one determined by social embeddedness, and the other by the relative proportions of tacit or codified knowledge involved in the production process.

We collected data on samples of businesses operating in two contrasting economic sectors within a single geographic area. We utilised the techniques of "quantitative interviews" (Johnson & Turner 2002) and "expanding selection" (Doreian & Woodard 1992) to concurrently collect network data and semi-structured qualitative data. We built a multiplex network graph, incorporating five distinct relations: customer, supplier, service, competitor and ally. Our analysis then combined quantitative network analysis with qualitative analysis within a "Concurrent Mixed Method" research design, using alternating and iterative strands of deductive and inductive inquiry. We adopted purposive sampling, followed by concurrent qualitative and quantitative (SNA actors, relations, attributes) data collection and analysis. Thus, in the typology of "Mixed Methods" research designs, it is a "Concurrent Nested Design" (Creswell et al. 2003).

Findings:

Network Overview

Figure 2 and Figure 3 below show graphs of the "complete" networks for both the "Food" and the "Digital" networks[†]. In these graphs we have aggregated the five distinct relations and additionally have symmetrised the ties. While aggregation and symmetrisation necessarily results in a loss of information, it also makes the networks more dense and the analytical procedures more robust. We could view this composite relation as a more abstract and general representation of "has business tie to" or flows of business-relevant knowledge. In particular our argument is that the aggregation of the five individual relations comprises the network of business relations within which firms determine strategy and from which they draw as a resource.

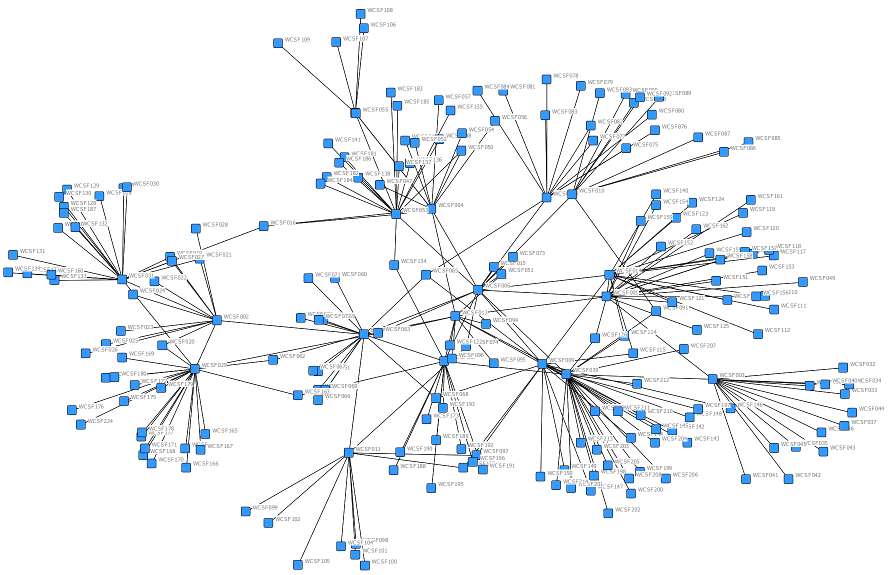


Figure 2. Food – "Complete" Network

An initial visual inspection of the two graphs suggests much in common, but with a few obvious divergences. The layout algorithm used is a "spring-embedder", which results in clusters of mutually connected nodes being placed close together, the most connected nodes at the centre, and "pendants" (nodes of degree 1) around the periphery. Both graphs have many such pendants but this is a side-effect of our method of data-collection: the pendants are firms which were mentioned as ties, but which lie outside the network boundaries (i.e. outside the geographic area or in a different business sector) and which were not themselves surveyed. In subsequent analysis we remove the pendants, and extract the "core" networks, which are comprised of the firms surveyed together with any others who were mentioned more than once.

The removal of these pendants highlights structural differences between the two networks, in that the Food network is a single connected component, whereas there are three components to the Digital network. In addition, there seems to be less of a clearly defined "centre" to the digital network.

[†] All of our analyses were carried out with the software UciNet and graphs were drawn with its visualization component NetDraw (Borgatti et al. 2002)

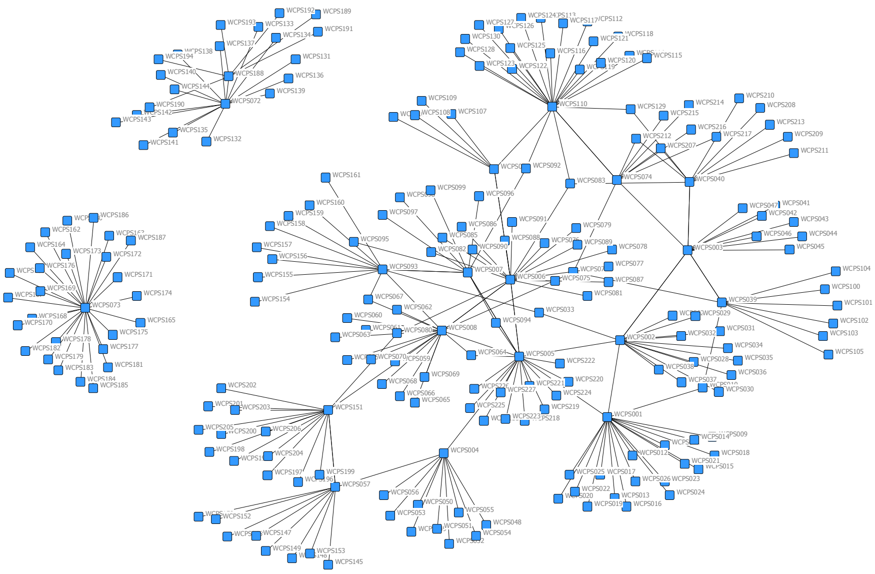


Figure 3. Digital– "Complete" Network

Chains and Networks

In discussion of supply-chains it has been conventional to visualise the relations between firms in a layout where the supplier in each dyad is placed on the left and the buyer on the right, and the resulting set of relations connected together in horizontal layers. When constructed in such a manner we identified those actors who seem, by visual inspection, particularly 'important" or "well-connected". In the Food network two actors (both local retailers) appeared central, whereas in the Digital network, three actors appeared central (these included two of the wireless broadband suppliers in the area). Both observations seem to make intuitive sense, although in the Food case it is shared customers who are important, while in the Digital case it is suppliers of a common infrastructure.

Social Network Analysis provides a number of definitions for whether an actor is "important", "well-connected" or "influential", mostly categorized under the concept of "centrality". Therefore we explored how network visualisation software might make the notion of centrality more amenable to visual interpretation, and how using formal definitions of centrality allows us to be more precise in identifying, quantifying and specifying the nature of an actor's "importance" in the network structure.

Network Centrality

The literature on Social Network Analysis provides a large number of formal definitions of centrality. Some go back to the beginnings of the discipline, and new ones are still being proposed (Bavelas 1948; Everett & Borgatti 2010). In our discussion here, and in our application of the techniques to our data, we will follow two influential syntheses of these ideas (Freeman 1978; Borgatti & Everett 2006). Freeman identified three principal types of centrality: degree, betweenness and closeness. He comments that each of these implies a different underlying model of communication process and of "how centrality might affect group processes" (Freeman 1978, p.238), with degree measuring "activity", closeness measuring "independence" and betweenness a measure of "control"

In our study degree is not an appropriate choice because of the way in which our data was collected: subjects were asked to name their "top suppliers", "top customers" and so on (this is called a "name generator" question in SNA). The number of alters enumerated varied hugely – from zero to ten or more, but it would not be reasonable to infer that a subject who listed ten alters was more "important" than one who listed two or three – the response would be dependent on so many other factors.

A popular measure of centrality based on (weighted) closeness is "eigenvector" centrality (Bonacich 1972). For this measure to be appropriate it is necessary that criteria be met on the relative variation accounted for by the eigenvectors and on the relative magnitudes of the eigenvalues. These criteria are not met for the Food network, and are only partially met in the Digital network. Betweenness measures however are a good fit both analytically and conceptually for our networks. The most central node, by the measure of "node betweenness" (Freeman 1977, Freeman 1980), is the one that falls on the greatest number of shortest paths (geodesics) between all other pairs of nodes in the network. This is a natural definition of "importance" if the network represents flows of information or exchange relations that are dependent on intermediaries. Freeman noted that such a network position is important for the maintenance of communication in the network and also as a coordinating role in group processes (Freeman 1978, p.221). All of these interpretations are important in our conception of business relations and networks.

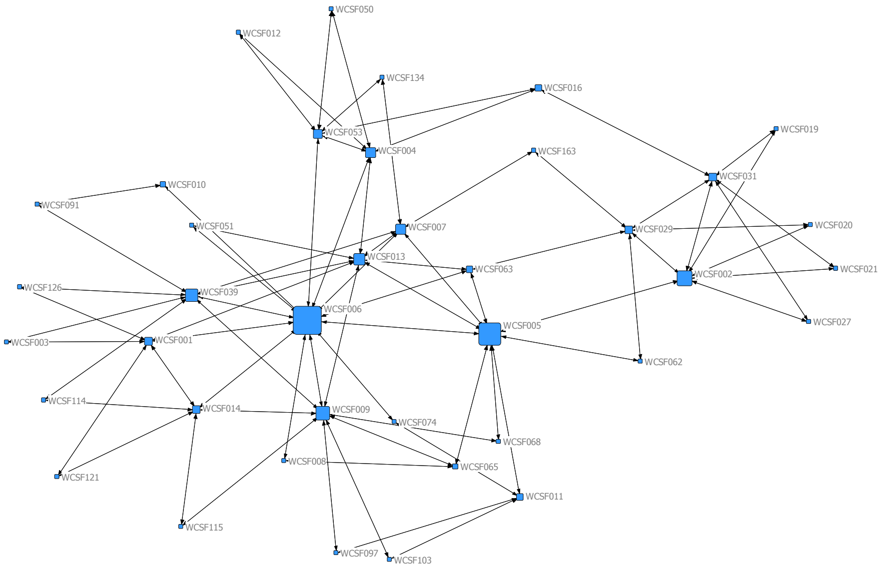


Figure 4. Food - Betweenness Centrality

The graph in Figure 4 picks out the two retailers, together with an actor who (drawing on the qualitative data) is often cited as a "role model" for firms who aspire to grow bigger, having moved from small-scale home production to a purpose-built production facility and international distribution. In the Digital network, none of the methods seem to fit well. The underlying reason for this is that the main component of the network (i.e. excluding the two smaller components) is really two separate groups, each with its own "centre".

Borgatti & Everett devised a typology of centrality measures based a cross-categorization into medial/radial and volume/length (Borgatti & Everett 2006, p.476). Within this typology degree, eigenvector and power centrality are all radial-volume methods, while betweenness is medial-volume. Borgatti & Everett point out that radial measures of centrality are unlikely to be appropriate unless the network is "one group" or essentially has a "core-periphery" structure. When the network is composed of two principal groups, betweenness is likely to identify as central those actors who "bridge" the gap between the groups. While this is another important aspect of group structure, it is not usually a good measure of centrality. In a later section we discuss techniques used for identifying subgroups, but for now we choose one such technique and analyse centrality within the resulting grouping.

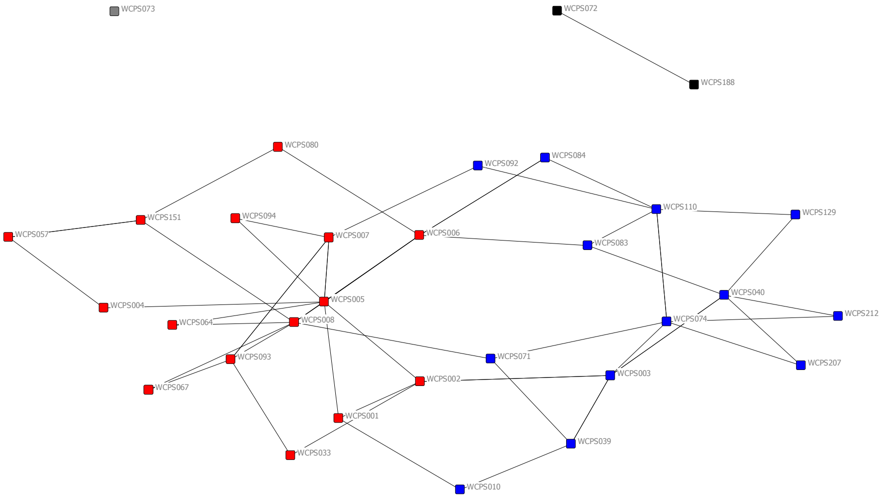


Figure 5. Digital - Newman-Girvan Subgroups (N=4)

Using Newman and Girvan's algorithm for identifying subgroups in the Digital network (Newman & Girvan 2004) we find two groups - on the left and the right of the main component, as presented in Figure 4. As we discuss later, these two subgroups are strongly geographic in composition, more or less east and west in the region studied. We then extract the two main subgroups and analyse centrality for them separately.

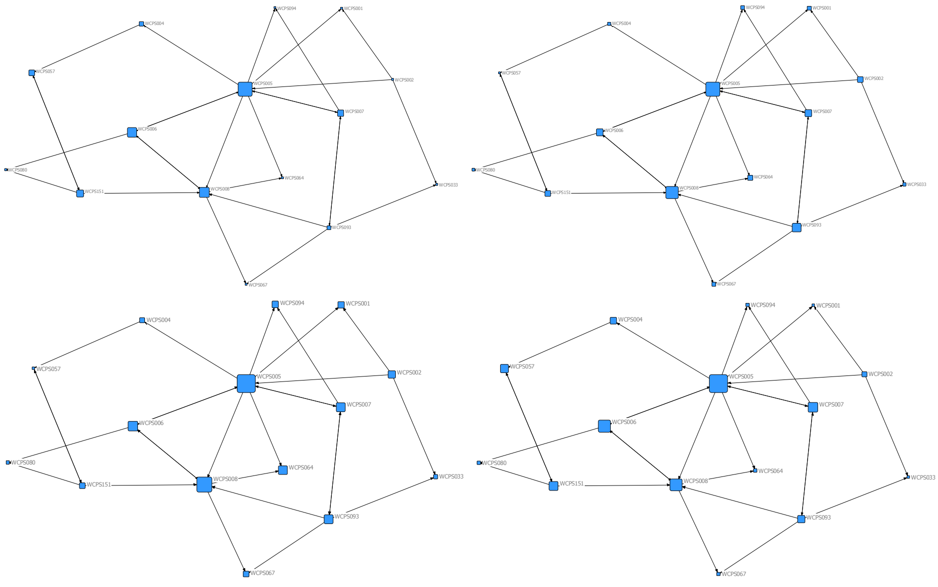


Figure 6. Digital - Four Measures of Centrality

Figure 5 shows four graphs of centrality for the first subgroup, one from each of Borgatti and Everett's four categories. The top-left is Freeman's (Node) Betweenness (medial-volume category); top-right is Information (Stephenson & Zelen 1989) which is a form of closeness that takes account of all paths, not just the geodesics and is a radial-length measure; bottom-left is Eigenvector (radial-volume) and bottom-right is Borgatti's Distance-Weighted Fragmentation (DF) (Borgatti 2006) which is in the medial-length category.

While there are differences in the centrality scores and in the ranking of the more peripheral actors, there are always two who are clearly "most central". These are a supplier of wireless broadband and a company which is rapidly growing and which was identified by "expert" authorities in the development agencies as prominent. So, as in the Food network, network analysis identifies a "role model" firm as central.

The second sub-group is more problematic for centrality analysis, with identification of central actors not being stable with respect to choice of measures and no clear distinction between central and non-central actors. It is possibly the case that is not really a cohesive group but rather is a residual or complement of the first group. In support of that claim we may note that the first subgroup comprises 15 actors, of whom 11 were surveyed, while the second group comprises 13 actors, but only 6 were interviewed and it contains 2 non-respondents and 5 "partners". On the other hand, the qualitative data does suggest that broadband supply was less often named as important in the second group; the local wireless supplier offers speeds that are not significantly higher than fixed (DSL) broadband, DSL is more widely available in this area; and also there is a fibre trunk available in a local technology park there (where actors from one of the minor components are located). So this group may indeed have a different network structure, given that broadband infrastructure supply conditions are markedly different.

Network Cohesion & Cohesive Subgroups

While centrality measures are concerned with identifying "key" actors within a network, another viewpoint in SNA focuses in a more "macro" way on the structural composition of the network itself and on "the structures within which individual actors are embedded." (Hanneman & Riddle 2005, p.95). In the context of our research design we chose the two economic sectors – Food and Digital – purposively in order to express dimensions relating to embeddedness, materiality of products, and codification of knowledge inputs. Based on theory we made a number of initial hypotheses, including an expectation that the Food network would have more connections (and more local ones) – a feature that has often been associated with conceptions of "social capital". A simple network-metric for this is density, and a related one is reciprocity – the extent to which ties are reciprocated or two-way (in a directed network). Within our networks however there is no significant difference in density (6%) and reciprocity is actually higher for the Digital network (21% versus 15%, although this is not significant in a network context).

We may look more closely at the question of network structure by seeking to identify local sub-structures, or what are called "cohesive subgroups" (Wasserman & Katherine Faust 1994, p.249). There are (again) many ways of understanding and defining such groups. We will follow Hanneman and Riddle's (2005, pp.148-149) categorization of the methods as "bottom-up" – starting from the dyad or triad and seeking to extend it outwards to larger groupings – or "top-down" – starting from the whole network and seeking to sub-divide it into more locally-dense parts. We illustrate and interpret our results using one method from each of these categories.

In our earlier study of the Food network (Sloane & O'Reilly 2010) we used the technique of p-Clique (NEGOPY) (Richards 1975) as an example of a "bottom-up" method[‡]. We related the presence of a pair of outliers from otherwise strongly cohesive groups to the nature of those two firms' business relations and to social embeddedness. The p-clique doesn't give any useful information in the case of the digital network, as there are no such outliers. Instead we will consider an analysis using 2-Cliques (i.e. an N-Clique, with N=2). These are a slightly relaxed definition of clique (a maximal complete sub-graph) in which each member is connected to every other member by a path of length less than or equal to 2 (i.e. "a friend of a friend" or connected through at most one intermediary). In Figure 7 below we required that the minimum clique size be 7, coloured the nodes by clique and set the layout to group the members of the clique close together. A pair of 2-cliques is clearly shown– in blue and in black. The higher density of ties within each clique relative to ties outside is also readily apparent.

[‡] P-Clique analysis was done with Pajek (Batagelj & Mrvar n.d.; de Nooy et al. 2005)

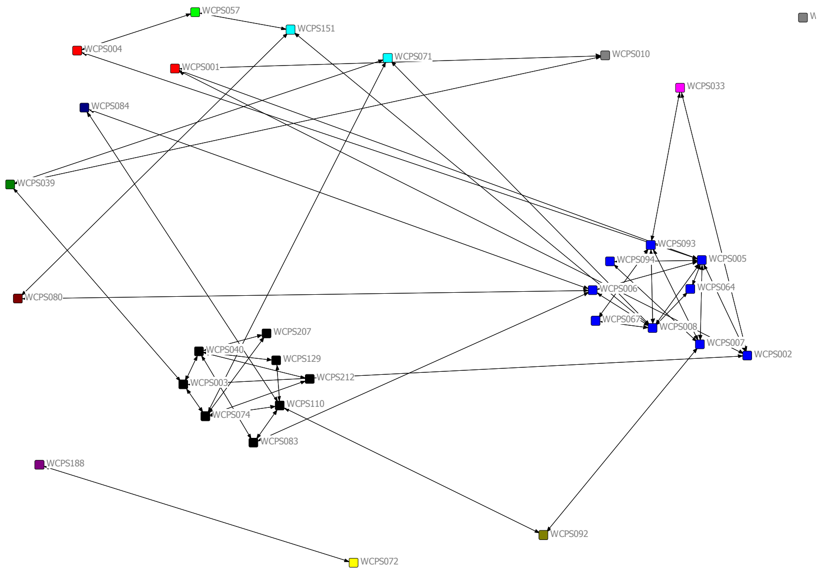


Figure 7. Digital - N-Cliques

These two subgroups are strongly correlated with geographic location – of the 8 members of the leftmost group, 7 are located at the eastern extreme of the region (out of 11 in total in that sub-region), and of the 9 members of the rightmost group, 6 are located in the western part (out of 9 in total in that sub-region).

As an example of a "top-down" method for identifying subgroups we have used Newman & Girvan's "community-detection" algorithm (Newman & Girvan 2004). This algorithm works by iteratively removing the edge with the highest betweenness score, and thus identifying subgroups by finding the bridges that connect them. In the case of the Digital network we earlier showed the results of Newman-Girvan for N=4, and explained it in terms of geography. Going again to a finer level of sub-grouping, with N=7, results in Figure 8. In this case both of the earlier sub-groups have sub-divided. One of the new sub-groups comprises those members of the "eastern" group who had been earlier placed within the "western" group. Another is a "far-west" sub-group, also previously contained in the" western" group. So these remain consistent with a "geographical" explanation. The final new sub-grouping comprises a number of interconnected businesses which are involved in producing print media as well as electronic media such as web-sites. This suggests that specialism plays a role, as it did in the Food network, but is subsidiary in this network to geographic proximity.

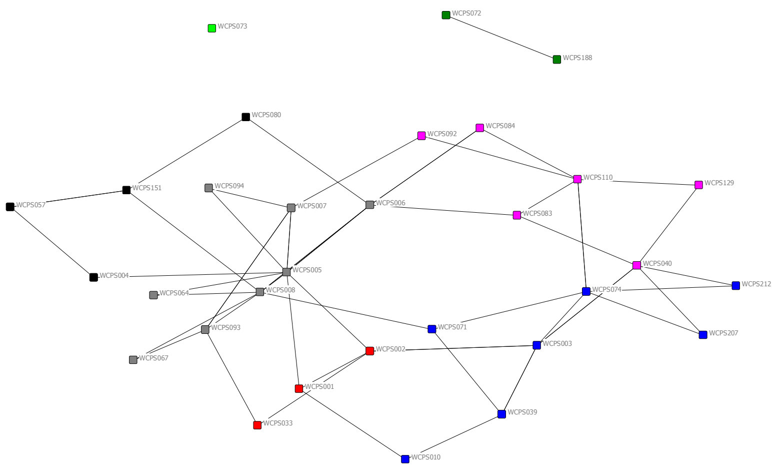


Figure 8. Digital - Newman-Girvan subgroups (N=7)

Discussion:

In our exploration of the contrasting structure of these two networks we have found differences in the type of actors who are central, in the patterning of subgroups, and in the nature of linkages across subgroups. Turning to the qualitative data we collected we can seek explanation for these differences.

Food production evidences commonality in production methods, at least within subsectors, and so actors report sharing of inputs and equipment. Thus the use of common ingredients and packaging creates links through shared suppliers. Sometimes those linkages strengthen and are formalised into joint purchasing alliances. In other cases the linkages remain informal, for example sharing or borrowing equipment when technical problems arise; sharing packaging materials in times of shortage or sudden demand; sharing knowledge when purchasing, maintaining or operating specialised equipment. Such arrangements are advantageous to the individual firm, especially considering the large capital investment and sunk costs that specialised production machinery represents for small firms. Such sharing also allows firms to respond to demand-side delivery commitments in a flexible way. These linkages – formal or informal – provide an explanation for why we see subgroups in the Food network being aligned along business-subsector divisions.

By contrast the Digital network has no real sub-sectors. Within this local area and the local network such businesses are relatively "thin on the ground", and actors feel more in common with one another than divergence along lines of technical specialism. Examining network graphs for the components of vertical relations or of competitors clearly illustrates this. Inputs (suppliers) and outputs (customers) are usually located outside the geographic area and rarely are common to pairs of actors. We do however observe some degree of local competition in locally-oriented services (e.g. website design), which is a likely explanation for the subdivision seen in the "eastern" sub-group. All of these businesses are "knowledge-based" but each occupies a very different niche. Thus sharing of knowledge - which is widespread and reported as very important to the actors - is primarily of general "business knowledge" and is often tacit. Codified knowledge inputs for these firms are widely divergent and generally accessed via internet resources. Without the "global pipeline" (Bathelt et al. 2004) provided by broadband ICT, these businesses report that they would not be able to operate in the region.

While sharing of tacit knowledge is primarily informal, "face-to-face", and spatially proximate within this network, the digital businesses do seek other geographically-dispersed sources of tacit knowledge through travel - what Torre has labelled "TGP" or "temporary geographical proximity" (Torre 2011, p.218) - telephone, and "Skyping". That last word was encountered frequently as a vernacular term for video-conferencing, not just among the digital businesses but even with otherwise very "traditional" farm businesses. As technological advances in ICT continue it seems likely that higher-bandwidth and more communication-rich technologies such as telepresence systems will further modify the boundaries of tacit-codified and spatially-relationally-proximate communication.

Consequently linkages between the actors in the digital network are not created by "supply-chain" links (suppliers or customers) but through alliances and service providers. Among service-providers, wireless broadband is particularly important to "digital" businesses, and so appears as central in our measured networks. For a variety of reasons the wireless broadband providers are geographically disjoint. The technology is sensitive to, and in large degree governed by, topographical factors. In other words, there is necessarily a "physical" network of transmitters, receivers and repeaters, and the placement of these is related to the topography, for example on high ground and within line-of-sight, and is constrained by transmission power and physical distance. A further reason for physical disjointness is business competition: in these relatively sparsely populated areas it is generally only feasible for one provider to operate. Regulatory licensing requirements also decrease the likelihood of multiple providers. The observed "network" consequence of all these factors is that we see sub-groups, centred on a wireless broadband provider, and correlated with geographic location. Sharing a provider - often the search for one by new entrants to the area - in turn creates linkages among the digital businesses, and so increases the density of local ties. Such inter-linkage between multiplex networks, contingent on physical or geographic, social and institutional factors was apparent throughout the study.

Conclusion:

A network-theoretic point of view has much to offer in researching the "new economy" – for example, "dualistic" structures (Glasmeier & Howland 1993) might be theorized as arising from processes of cluster formation and co-evolution. Our research leads us to develop a conceptual framework, close in spirit to Storper's "trinity" of "technologies-organizations-territories" (Storper 1997), that comprises: (i) spatial processes of agglomeration and dispersal; (ii) social processes of culture, trust and embeddedness; (iii) Knowledge – both codified and tacit – and processes of its communication and formation; together with (iv) the economic "imperative" that seeks innovation and competitive advantage (Storper & Walker 1989; Porter 2003)

This last component has the effect of putting the whole assemblage into motion, as it were, bringing in processes of evolution over time and, in particular, of economic growth and success or, conversely, of stagnation and decline. Our framework is organized around "networks" – the social ones (friendship, trust, kinship etc.) and the economic ones (communication, cooperation, competition, exchange etc.) along with the physical infrastructure of the broadband network. It is within spatial areas that we most clearly see the effects of the degree to which these multiple networks are or are not coterminous. Thus actors may be spatial "neighbours", or even "social neighbours", but may not have any coincidence in their economic networks – in this regard it is interesting to find that social embeddedness was important to 'high tech entrepreneurs' in terms of 'a place to live' and of less importance to the success of their enterprise.

We find the mixed methods research design useful in that it combines and integrates both strands of analysis and thus deepens understanding of how networks affect business strategy and conversely how participants, through their pursuit of opportunity and efficiency, create and modify networks.

REFERENCES:

Aydalot, P. and Keeble, D. eds., (1988) *High Technology Industry and Innovative Environments*, London: Routledge.

Batagelj, V. & Mrvar, A., (n.d.) Pajek - Program for Large Network Analysis, Available at: http://vlado.fmf.uni-lj.si/pub/networks/pajek.

Bathelt, H. Malmberg, A. & Maskell, P., (2004) Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. Progress in Human Geography, 28(1), pp.31-56.

Bavelas, A. (1948) A Mathematical Model for Group Structures. Human Organization, 7(3), p.16–30.

Becattini, G. (1990) The Marshallian Industrial District as Socio-Economic Notion. In *Industrial Districts and Inter-Firm Co-Operation in Italy*. Geneva: International Institute for Labour Studies (IILS), pp. 37-51.

Bonacich, P. (1972) Factoring and Weighting Approaches to Status Scores and Clique Identification. Journal of Mathematical Sociology, 2, p.113–120.

Borgatti, S.P. (2006) Identifying Sets of Key Players in a Social Network. *Computational & Mathematical Organization Theory*, 12, pp.21-34.

Borgatti, S.P. and Everett, M.G. (2006) A Graph-Theoretic Perspective on Centrality. Social Networks, 28, pp.466-484.

Borgatti, S.P. and Li, X. (2009) On Social Network Analysis in a Supply Chain Context. *Journal of Supply Chain Management*, 45(2), p.5–22.
Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002) ucinet for Windows: Software for Social Network Analysis, Harvard, MA: Analytic Technologies.
Cairncross, F. (1998) The Death of Distance: How the Communications Revolution Will Change Our Lives, Orion Business Books, London
Castells, M., (1996) The Information Age. Economy, Society and Culture. 1st edition 1996-1998, 2nd edition 2000-2004., Oxford; Malden, MA: Blackwell.
Choi, T.Y. and Kim, Y. (2008) Structural Embeddedness and Supplier Management: A Network Perspective. *Journal of Supply Chain Management*, 44(4), pp.5-13.
Choi, T.Y. and Wu, Z. (2009) Taking the Leap from Dyads to Triads: Buyer-Supplier Relationships in Supply Networks. *Journal of Purchasing and Supply Management*, 15(4), pp.263-266.
Collins, P. (2007) Information Ireland: The attraction, the reality and never ending geography, European Planning Studies, 15(1): 67-86.
Creswell, J.W. et al. (2003) Advanced Mixed Methods Research Design. In Handbook of Mixed Methods in Social & Behavioral Research. Thousand Oaks, CA: Sage Publications, Inc., pp. 209-240.
Doreian, P. and Woodard, K.L. (1992) Fixed List versus Snowball Selection of Social Networks. *Social Science Research*, 21, pp.216-233.
Entwisle, B., Faust, K., Rindfuss, R., R. and Kaneda, T. (2007) Networks and Contexts: Variation in the Structure of Social Ties. American Journal of Sociology, 112(5), p.1495–1533.
Everett, M.G. & Borgatti, S.P. (2010) Induced, Endogenous and Exogenous Centrality. Social Networks, 32(4), pp.339-344.
Faust, K., forthcoming. Comparing Social Networks. In 7th UK Social Networks Conference. Greenwich, UK.
Freeman, L.C. (1977) A Set of Measures of Centrality Based on Betweenness. Sociometry, 40(1), pp.35-41.
Freeman, L.C. (1978) Centrality in Social Networks: Conceptual Clarification. Social Networks, 1, pp.215-239.
Freeman, L.C. (1980) The Gatekeeper, Pair-Dependency and Structural Centrality. Quality & Quantity, 14(4), pp.585-592.
Glasmeier, A. & Howland, M. (1993) Service-Led Rural Development: Definitions, Theories, and Empirical Evidence. International Regional Science Review, 16(1-2), pp.197-229.
Graham, S. (1998) The End of Geography or the Explosion of Place? Conceptualising Space, Place and Information Technology, Progress in Human Geography, 22(2): 165-185.
Hanneman, R.A. & Riddle, M. (2005) Introduction to Social Network Methods, Riverside, CA: University of California, Riverside.
Johnson, B. & Turner, L.A. (2002) Data Collection Strategies in Mixed Methods Research. In A. Tashakkori & C. Teddlie, eds. *Handbook of Mixed Methods in Social & Behavioral Research*. Thousand Oaks, CA: Sage Publications, pp. 297-320.
Kelle, U. (2001) Sociological Explanations Between Micro and Macro and the Integration of Qualitative and Quantitative Methods. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 2(1). Available at: http://www.qualitative-research.net/index.php/fqs/article/view/966.
Kim, Y. et al. (2011) Structural Investigation of Supply Networks: A Social Network Analysis Approach. *Journal of Operations Management*, 29(3), pp.194-211.
Kotkin, J. (2000) The New Geography: How the Digital Revolution is Reshaping the American Landscape, Random House: New York.
Lundvall, B.A. & Johnson, B, (1994) The Learning Economy. *Industry & Innovation*, 1(2), pp.23-42.
Maskell, P. & Malmberg, A. (1999) Localised Learning and Industrial Competitiveness. *Cambridge Journal of Economics*, 23(2), pp.167-185.

Newman, M.E.J. & Girvan, M. (2004) Finding and Evaluating Community Structure in Networks. Physical Review E, 69(2), p.026113.
de Nooy, W., Mrvar, A. & Batagelj, V. (2005) Exploratory Social Network Analysis with Pajek illustrated edition., Cambridge, UK: Cambridge University Press.
O'Brien, R. (1992) *Global Financial Integration: The End of Geography*, Council on Foreign Relations Press.
Porter, M.E. (2003) The Competitive Advantage of Regions. Regional Studies, 6(7), pp.549-578.
Richards, W.D. (1975) A Manual for Network Analysis (Using the NEGOPY Network Analysis Program), Stanford, CA: Stanford University, Institute for Communication Research. Available at: http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED114110 [Accessed May 2, 2010].
Sassen, S. (2001) *The Global City: New York, London, Tokyo*, Princeton: Princeton University Press.
Saxenian, A., 1994. Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Cambridge, MA: Harvard University Press.
Scott, A.J. (1993) Technopolis: High-Technology Industry and Regional Development in Southern California, University of California Press.
Sloane, A. & O'Reilly, S. (2010) The Emergence of Supply Chain Eco-Systems - A Social Network Analysis (SNA) Perspective. In Configuring Next Generation Supply Chains. Proceedings of the 15th International Symposium on Logistics (ISL 2010). Kuala Lumpur, Malaysia: Centre for Concurrent Enterprise, Nottingham University Business School.
Stephenson, K. & Zelen, M. (1989) Rethinking Centrality: Methods and Examples. *Social Networks*, 11(1), pp.1-37.
Storper, M., 1997. The Regional World, New York, NY: Guilford Press.
Storper, M. & Walker, R. (1989) The Capitalist Imperative: Territory, Technology and Industrial Growth, Oxford: Basil Blackwell.
Torre, A. (2011) The Role of Proximity During Long-Distance Collaborative Projects. Temporary Geographical Proximity Helps. Int. J. Foresight and Innovation Policy, 7(1/2), p.3.
Wasserman, S. & Faust, K. (1994) Social Network Analysis: Methods and Applications, Cambridge: Cambridge University Press.

BUILDING CAPACITY IN THE THEORY OF HUMANITARIAN LOGISTICS

Andor Baan, Elizabeth Barber***
*Ministry of Defence, Du Moulinkazerne, Het Zeisterspoor 19,Soesterberg, Gebouw D7
***University of New South Wales, Australian Defence Force Academy,*
Canberra, Act 2601, Australia.

ABSTRACT

Purpose:
The purpose of this paper is to build the capacity of the logistical theory relating to humanitarian logistics.

Research approach:
A literature review is provided to demonstrate that some of the theoretical aspects of humanitarian logistics are currently being developed as the need for humanitarian aid increases around the world. The practical applications of the provision of humanitarian aid are leading the development of the supply chain theoretical concepts. This paper directly focuses on developing theory that can be applied to humanitarian supply chains to improve their overall efficiency and effectiveness. The limited literature in humanitarian supply chains does not address the transition processes between the humanitarian phases. Yet it is in these transition areas where inefficiencies occur. Our approach focuses on these transition areas between both the activities along the total humanitarian supply chain and across the typical humanitarian phases. The paper provides an analysis of the various phases and the logistics functions dominating each phase. It discusses the transition phases to show the current gap in the literature and the applications of logistics in the humanitarian supply chains. The paper demonstrates the current failures in the supply chains and offers solutions to improve the overall efficiency and effectiveness to the total humanitarian supply chains.

Findings and Originality:
The improved awareness and knowledge gained from improving the transition of logistical support when passing over leadership from one controlling entity to another entity between the humanitarian aid stages will lead to greater efficiencies. Thus this paper fills a gap in the literature on humanitarian logistics. The choke points along the supply chain as the physical, financial and information flows falter due to the changeover of effective logistical support will be minimised.

Research impact:
It lays the foundations for further research in the critical logistical transitions areas of providing humanitarian aid.

Practical impact:
The developed framework will improve the applications of provision of humanitarian aid between NGOs, military, United Nations affiliates and the host country logisticians during the transition phases.

Keywords:
Humanitarian logistics, Humanitarian Aid; Supply Chains

INTRODUCTION

During supply chain operations delivering humanitarian aid, the various participants interface their operations through different mechanisms such as dedicated institutions, competition and contracting. These interfaces during the logistical transition points where tasks and responsibilities are transferred between participants become blurred and subsequent logistical efficiencies can occur. Furthermore during the transition between the various phases of humanitarian aid, from the preparedness, the immediate disaster relief, the reconstruction and redevelopment phases and the transition from the humanitarian agencies to the host nation handover more logistical overlaps occur. Little emphasis has been given to these transition elements in humanitarian supply chains which this paper aims to alleviate somewhat.

LITERATURE REVIEW – COORDINATION ASPECTS OF HUMANITARIAN LOGISTICS

The literature according to Kovacs and Spens (2007) on humanitarian logistics 'is scant'. (p.100) Further there is little academic literature and more practitioner based journal articles which tend to concentrate on either aid work or disaster relief. No literature published either in the academic of practitioner based journals focused on the logistical overlaps during the transition phases of humanitarian aid.

The recognition of humanitarian phases and the need for different logistical requirements during each phase is widely acknowledged. (Long, 1997; Cottrill, 2002, Safran, 2003, Lee and Zbinden, 2003, Pettit and Beresford, 2006). Most of these articles focus on the disaster phase after acknowledging there are subsequent phases of humanitarian logistics. The preparedness phase has been seen by Dignan (2005) to require a suite of common substance foods and medicines which should be stockpiled in strategic locations as preparedness SKUs for disaster relief logistical needs. (Thomas, 2003)

Confusion and extreme challenges of coordination of logistical players in delivering and distributing humanitarian aid within the immediate disaster area of operations has been recognized. Long and Wood (1995) very early on noted the challenges of coordinating the many different global aid agencies and local agencies in assisting logistics in disasters. Oloruntoba (2005) argues that local expertise should be used and should be included in the planning and decision making. This local expertise should be integrated with the international expertise of the international aid agencies and used to a much greater extent than currently. Perry (2007) in her literature review of humanitarian logistics supported the notion that the coordination of locally inclusive needs requires integration in the delivery of aid and without such coordination, marginalization and dispossession will contribute to the victims' vulnerability. Her development of a holistic model of preparedness, response and aftermath highlighted the need for coordinated strategic planning. Nevertheless it neglected the transition stages between the three phases.

The need for coordinating of information systems in support of humanitarian logistics was expounded by Tomasini and van Wassenhove (2004). Information plays a strong enabling role in coordinating the various participants' operations along the humanitarian supply chain. (Zhang, Zhou and Nunamaker, 2002; Maxwell and Watkins, 2003) It enables greater visibility and facilitates more effective responses to the needs of the victims. However uncertainty of demands in the affected areas due to the destruction of infrastructure and possibly the remoteness of the disaster areas make information sharing and coordinated crucial. (King 2005)

Thus although the literature recognizes the need for coordination of supply chain participants and coordination of these services during the transition of the humanitarian aid phases little has been written about it. Nevertheless the recognition for the need for coordination at the interface between supply chain participants has led to the development of dedicated logistical institutions to support these interfaces and improve the efficiencies and effectiveness of the overlap of humanitarian logistical services.

INSTITUTIONS AT THE HUMANITARIAN LOGISTICAL INTERFACE

This section will discuss the most important institutions that provide a linkage for the sharing of information and the coordination of logistical activities.

OCHA – Coordination of Humanitarian Affairs

OCHA often takes a leading role for the overall coordination of the humanitarian relief efforts. OCHA can develop humanitarian information centers (HICs) in the affected areas to enable the various UN agencies, NGOs, private contractors and other participants (including the local bodies and host nation's military organisations) to obtain information of the affected areas, victims' needs. It acts as a conduit for information sharing and in effect reduces some of the competitive nature of the relief operations as a lead co-ordinator of activities. This is a Herculean task. The challenges of coordination related to the different types of humanitarian organisation ranging from supranational aid agencies, governmental agencies, non-governmental organisations, religious charity groups, specialist groups and the host nation's domestic organisations, both governmental and non-governmental are as time consuming as they are important. (Kovacs and Spens, 2009) Civil-military coordination is also a delicate issue as some organisation can or cannot collaborate with various military groups. (Pettit and Beresford, 2006) As far as the UN is concerned sometimes OCHA might not always have the requisite technical skills for the level of logistics coordination which most emergency operations demand and thus developed the UNJLC.

UNJLC – United Nations Joint Logistics Centres

The UNJLC provides an interface between local authorities and humanitarian agencies for logistical services. When deployed, the UNJLC is integrated into the UN's response coordination structure on the ground. The UNJLC is configured to support two response models: inter-agency logistics coordination only or inter-agency logistics coordination plus asset management (for example a donated fleet of aircraft – see Kaatrud, Samii and Van Wassenhove, 2003) UNJLC is a specialised centre of inter-agency coordination that deals exclusively with logistical issues in increasingly complex operational environments. It is expected to make the best use of limited and often expensive resources and assets.

UN-CMCoord - UN Civil Military Coordination Section

Another important institution that acts as an interface between supply chain participants is the UN Civil Military Coordination Section. Frequently in fragile states or complex emergencies where conflict exist the UN-CMCoord officers will be required to negotiate solutions on issues arising on either the military or civilian side of supply chain interfaces delivering humanitarian aid. These issues can involve the policy dimensions of areas such as security, transportation, communications, medical evacuation etc. (UN-CMCoord, 2008) A peace support operation can take place in environments populated by multiple civilian institutions, humanitarian organizations and an extremely challenging number of problem situations which may not be precisely military in nature. This complexity has increased the importance of managing the civil-military interface, particularly that between the military and the humanitarian community. The military/humanitarian involvement has shifted from a co-existence to a more acceptable co-ordinated approach. (Reitjens, 2006) Military involvement, especially in humanitarian logistical operations, is gaining greater acceptance from the public, the media and aid organizations and thus increasingly civil-military cooperation (CIMIC) is used as an acceptable interface both by supply chain partners on both sides of the aid spectrum. (Rietjens, 2008)

PICs – Press Information Centres

PICs in the organization of the different supply chain participants improve the interface between the media and the participants along the chain. The presence of the media in humanitarian situations has become more important, especially the case since the 9/11 disaster where the media came to the fore in disseminating information. The more public and large the international organisation is or the more sensitive the locality is, the more important the media's influence. (Limot and Nossek, 2006) PICs provides a facility as an acceptable interface with all the world's media. The atmosphere generated within this organization has a major impact on the successfulness of operations or otherwise as seen through the media's lenses.

Competition at the Interface

Competition often exists at the interface between the participating members of the supply chain which can result in positive or negative outcomes.

Information is often used to gain competitive advantage. Oloruntoba and Gray (2009) discuss propaganda, public relations and counter information operations whilst Pettit and Beresford, (2009) state information management is crucial and the speed with which it can be used can critically impact the effectiveness of the logistical response. Their argument is that the achievement of a balance in the use of communication systems can lead to greater effectiveness. A balance of using cell phones, IT compatibility and emails can all improve the coordination.

Intense competition between UN agencies, international NGOs and more recently, for-profit organisations occurs. These organisations compete for media attention scarce donor funds, (Oloruntoba and Gary, 2009) the high profile projects, (Rietjens, Voordikj and De Boer, 2007) and connections with the beneficiaries. Competition increases the chance of conflicts amongst the supply chain participants. The civil-military interface with western governments sees organizations coming into conflict more often than working together in humanitarian aid deliveries. As agencies are forced to compete for limited resources in pursuit of their own institutional interests, (often the most important being getting the credit via media coverage) and thus more funding and resources for aid programmes, conflict is inherent in aid organisations. The amount of resources collected by the supply chain participants and their associated donors is directly related to the operations the agencies are able to set up and the amount of logistical support such operations require. The length of the flow and the volume of the logistical flows into the affected disaster areas also become competitive. When there a choke points such as limited port facilities or warehouse space allocated for distribution centres outside the disaster area, competition is fierce in order to one of the first organisations to supply much needed aid.

On the other hand, competition increases cost awareness of the supply chain operations. Participants have to compete to get contracts which reduce the overall humanitarian logistical services. As a result specialist managerial techniques and systems based on profit organization logistical services to improve the visibility and accountability of supply chain flows have been adapted to humanitarian supply chain operations. (Beamon and Balcik, 2008) The UN cluster approach and its establishment of agencies such as UNJLC not only serve the purpose of coordinating relief support but also to reduce the competition between participating providers. (Kovacs and Spens, 2009)

There are seven core participants involved in the immediate disaster relief area.

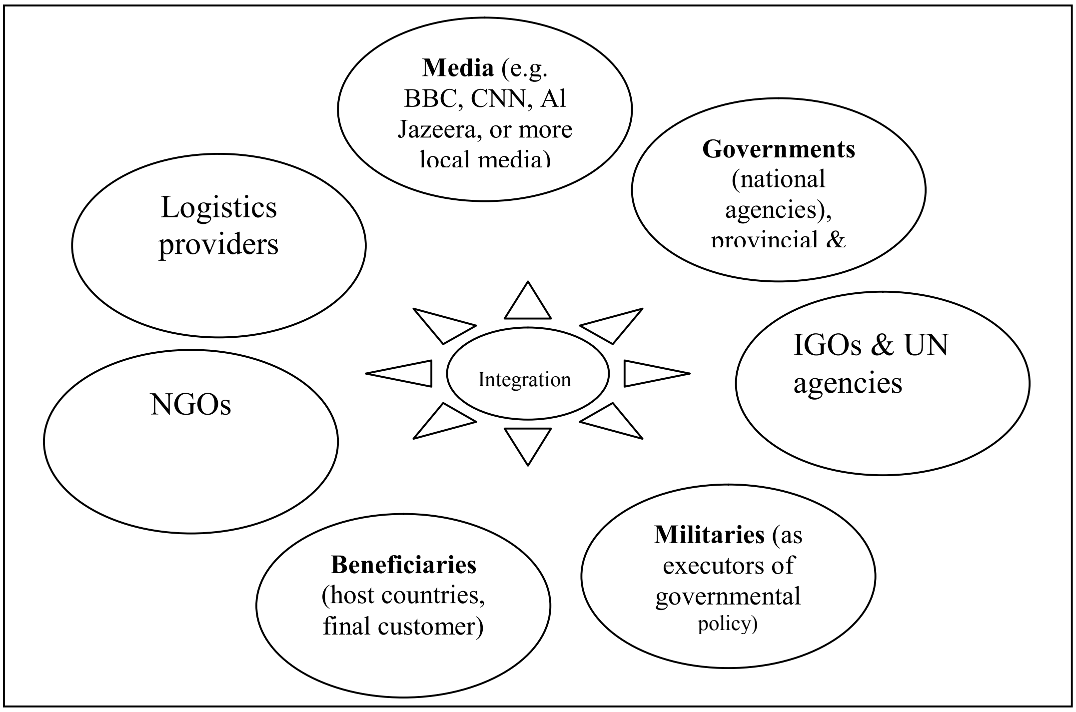


Figure 1 – The Seven Participant Model (source: Authors)

Overlap of logistical activities amongst supply chain participants

The supply chain contributions by the various network partners often overlap, because they are executed at the same location, at the same time or because they involve similar tasks. The participants need to align their contributions by sharing information and resources, improve planning, specialising in operational tasks and eventually being more collaborative, coordinated and less competitive. Collecting and processing information to achieve collaborative planning in highly complex, volatile and harsh environments has positive and direct influences on the overall decision making processes within the supply network. The process is typically very dynamic and must be adaptable. (Reitjens, Voorkijk and Dr Boer, 2007). Overlap can also be caused by lack of pre disaster planning, differential access to power, institutional deficiencies and lack of adaptive planning. Overlap can create both positive and negative influences on the successfulness of the humanitarian supply chain. On the positive side, experienced humanitarian logisticians almost always have overlapping tasks and responsibilities due to risk mitigation processes to ensure certainties of supply. On the negative the supply chain leader can often use the overlap to increase their power and influence at the expense of competing participants. (Shemella, 2006) Often there might exist instances where on participant has the authority but another participant has the resources needed to undertake the operation. A tense rivalry can arise between NGOs competing for donor resources and they are consequently hesitant to give up their position of authority.

The overlap in logistical providers in the private sector and the humanitarian sector can be significant. Although Kovacs and Spens (2007) identified some distinguishing features between business and humanitarian logistical providers, there exist some overlaps which can lead to greater cooperation. Van Wassenhove (2006) argues that there is a lot that business logisticians can learn from the highly uncertain humanitarian supply chain operations.

Overlap between military and civilian logistical services is also seen as an issue in some areas. The tasks and involvement of the military in humanitarian assistance can be broadly divided into three main categories; namely (i) fostering a level of security for the civilian population and the humanitarian organisations, (ii) supporting the logistics of the civilian humanitarian organisations, and (iii) providing direct assistance to those in need by filling the vacuum that might exist in the provision of supply to meet the needs of the local civilian population and societies. The third category causes problems. Humanitarian stalwarts claim that military involvement upsets the neutrality and impartiality that is the keystone of the humanitarian philosophy. It is often argued that the military-political motives distort the humanitarian efforts. (Kelly, 1996)

The military especially need to maintain adaptive structures that allow interfacing with non-military organizations. Transitional challenges regarding whom to handover to and if there is any individual NGO or other organization with sufficient authority to hand over to once the military have secured the region, finished their supporting role or completed the provision of direct humanitarian assistance. The supply chain interfaces are many and varied. Rarely does one participant within a supply chain deal only with the forward or backward participant in the chain. Humanitarian supply chains are typically dynamic supply networks with many humanitarian organisations moving in and out of various activities as their resources permit their level of involvement. All humanitarian organisations face the problem of who to pass over their logistical tasks to once their efforts are complete. The use of the coordinating bodies such as UNJLC is tasked with assisting these transitions. The CM-Coord section is also tasked with assisting the military/civilian transitions.

Rollins (2001) discussed how as the mandated civil organizations and local authorities became more capable of delivering the logistical support needed, the military involvement within their areas of responsibility should experience a corresponding decline in activities.

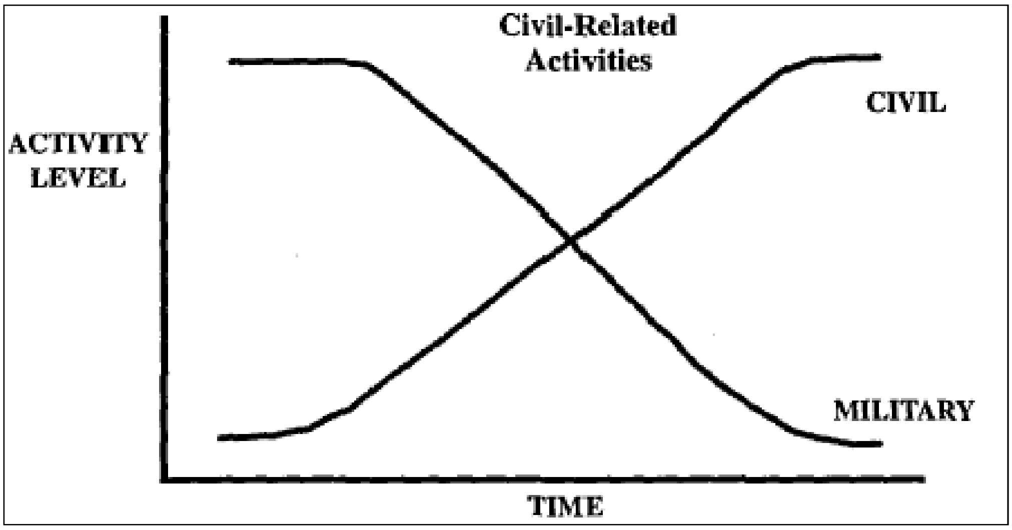


Figure 2 – Correlation of civil and military transitions in civil related activities
Source: Rollins, 2001

Figure 2 above illustrates a simplistic representation of the transition between civilian and military involvement. Nevertheless the model identifies the need for a seamless transition which can be far reaching. The civilian organizations taking on the responsibilities might have to be trained on the ground in some areas, for example secure information services. The civilian organizations have to be sufficient and efficient in maintaining the sustainability of the supply chain and the dispersion of activities and tasks that various civilian organisation take on and how they change the operations have to be addressed and integrated with all other supply chain participants' tasks.

The lines of activities and plans for transition need to be established by the supply chain leader (military or civilian). The UNJLC initially might take on the coordinating role but not the leading or dominant supply role in the humanitarian supply chain. From a military perspective, which can become extremely delicate, particular transitional problems can occur. There may be great pressure on military organizations, not least moral, to become embroiled in a wide range of humanitarian and reconstruction activities. All these activities appear laudable in their own right, however, without a critical path from the military initial engagement of a particular activity through a variety of carefully planned milestones towards the transition of responsibility to a civilian organisation the possibility of 'military' creep might occur. Military organizations then find themselves embedded in activities which extraction proves difficult. Rather than a smooth transition occurring as shown in Figure 2 above both military and civilian organizations become more embedded in the area of operations, functioning in parallel and both finding extraction difficult and exceeding their terms of engagement.

Focussing on timely transitions for both military and civilian organisations within humanitarian supply chains is crucial for improving both the efficiency and effectiveness of the provision of aid. The supply chain leader needs to be established to work closely with UNJLC as well as the other key supply chain participants. Agreement regarding the sharing of responsibilities, establishing and maintaining durable and mutually beneficial relationships, identifying capabilities and transition mechanisms are necessary.

So far the discussion has concentrated on transitions of responsibilities of tasks within the humanitarian supply chain without any recognition of which phase of humanitarian aid the supply chain is operating in. This section has just concentrated on the transition processes between and amongst the supply chain participants. The next section will discuss the transitional requirements between the humanitarian phases.

Overlap of logistical activities between the humanitarian phases

Using the more comprehensive framework of the cyclical disaster management model (DMC) of humanitarian aid demonstrated by Safran (2003), the main phases in the delivery of humanitarian aid include: the disaster event and immediate emergency relief stage; the recovery stage which covers the restoration, rehabilitation and reconstruction; the prevention stage which includes construction, preparedness, mitigation, early warning systems etc. Each of these stages needs different logistical support. The transition of between these humanitarian stages must be integrated with a smooth transition of logistical activities and supply chain participants responsibilities and roles. Figure 3 shows the various stages in a sequential diagram to highlight the transition stages.

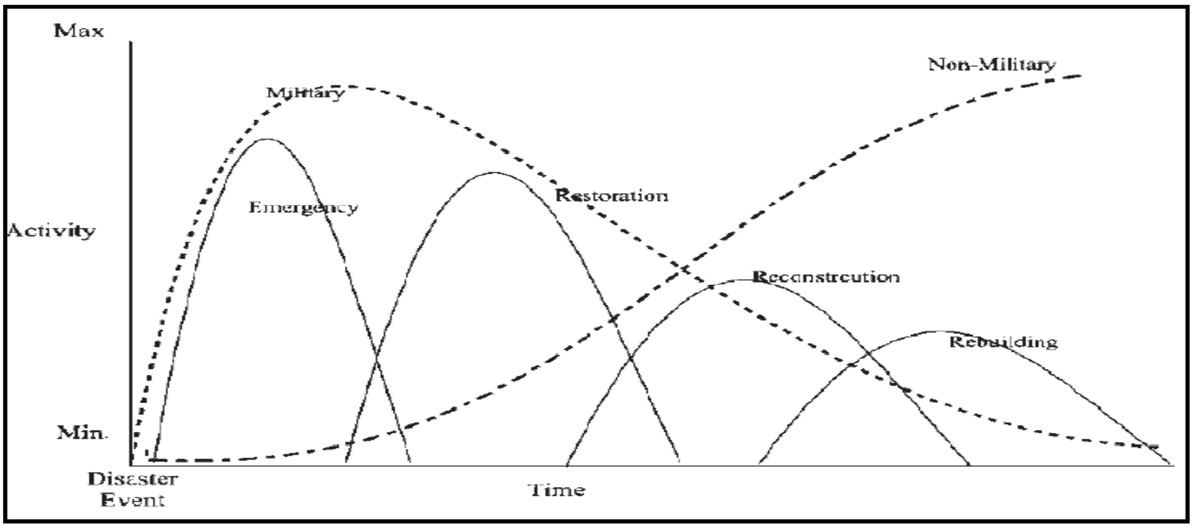


Figure 3 – Transition Interfaces between Humanitarian Phases over Time (Source: Hass, Kates and Bowden, 1977)

Figure 3 above clearly shows the transition overlaps between the emergency, restoration, reconstruction and rebuilding phases. It is limited in that it does not cover the more comprehensive humanitarian stages that the DMC demonstrates. Nevertheless it is suffice to show the importance of the transition areas in the delivery of humanitarian aid.

Little attention has been given to these transition points over the last thirty years. In 2001 Rollins discussed the civilian military transitions between the broad areas of crisis and stabilization. In 2005 Williams provided a demarcation table broken into four phases of planning, emergency response, subsequent recovery and local transition and integration of activities by military, civilian and local organisations.

Pettit and Beresford (2005) provided an in depth transitional model based on strategy planning. In their 2009 paper they further refined these points and spoke of the different combinations of organisations involved in the different stages of humanitarian aid, the changes in the strategic planning requirements of each organization across the humanitarian phases. They argued that where aid agencies develop long term relationships with suppliers for items commonly required throughout the humanitarian phases, stronger bridges will be made across the various phases of the disaster.

Kovacs and Spens (2007) provided a framework combining the perspectives of different actors providing aid in disaster relief operations with the three different phases of preparation, immediate response and reconstruction. They saw that each participant in the supply chain had to take the contextual differences between humanitarian and business logistics practices with humanitarian logistics practices morphing into more business like logistic practices over time in the reconstruction phase. They saw the involvement of global private (for profit) organisations such as DHL and TNT logistics who have recently established partnerships with the United Nations as a privatisation of the disaster response activities. Such privatizing of the disaster response logistics could revolutionize the response process.

During the various phases, overlapping tasks and scarcity of resources lead to closer collaborative efforts and greater interdependencies in humanitarian logistics. Cooperation can reduce duplication of tasks to some extent but above the collaborative planning, the information sharing and strategic leadership will enhance the efficiencies involved in the transition processes involved in humanitarian logistics. Although NGOs continue to be fairly territorial and protective of their distinctiveness, many of them collaborate closely with semi-military and military forces. The intertwining of militaries with bilateral and UN aid agencies have meant it is quite difficult for NGOs not to deal with all other actors involved in humanitarian aid. Indeed in complex emergencies it is fairly impossible for all logistical participants not to remain detached from the military presence.

CONCLUSION

The dynamics of logistical needs across phases and the rapid changes of actors involved in the various sections along the total humanitarian supply chains means that greater emphasis will be placed on these transition points. A plethora of efforts are not being seen to enhance coordination and collaboration in the provision of relief, reconstruction, rehabilitation and redevelopment. These efforts need to target the transitional processes in the logistical provisions to all phases across the humanitarian disaster management cycle.

REFERENCES

Beamon, B.M. and Balcik, B., (2008), Performance measurements in humanitarian relief chains, *International Journal of Public Management*, Vol. 21, No. 1, pp. 4-25.

Cottrill, K., (2002), Preparing for the worst, *Traffic World*, Vol. 266, No. 40, p. 15.

Dignan, L., (2005), Tricky currents; tsunami relief is a challenge when supply chains are blocked by cows and roads don't exist, *Baselin*e, Vol. 1, No. 39, p. 30.

Kaatrud, D.B., Samii, R. and Van Wassenhove, L.N., (2003), UN Joint Logistics Centre: a coordinated response to common humanitarian logistics concerns, *Forced Migration Review*, Vol. 18, pp. 11-14.

Kelly, C., (1996), Limitations to the Use of Military Resources for Foreign Disaster Assistance, *Disaster Prevention and Management*, Vol. 5, No. 1, pp. 22-29.

King, D., (2005), Humanitarian knowledge management, in Carle, B. and Van De Walle, B. (Eds) *Proceedings of the Second International ISCRAM Conference*, Brussels, Belgium, pp. 1-6.

Kovacs, G. and Spens, K.M., (2007), Humanitarian logistics in disaster relief operations, 99-114.

Kovacs, G. and Spens, K.M., (2009), Identifying challenges in humanitarian logistics, *International Journal of Physical Distribution & Logistics Management*, Vol. 39, No. 6, pp. 506-528.

Lee, H.W. and Zbinden, M., (2003), Marrying logistics and technology for effective relief, *Forced Migration Review*, Vol. 18, pp. 34-35.

Limot, Y. and Nossek, H., (2006), The Military and the media in the twenty-first century: Towards a new model of relations, *Israel Affairs*, Vol. 12, No. 3, pp. 484-510.

Long, D., (1997), Logistics for Disaster relief: engineering on the run, *IIE Solutions*, Vol. 29, No. 6, pp. 26-29.

Long, D.C. and Wood, D.F., (1995), The logistics of famine relief, *Journal of Business Logistics*, Vol. 16, No. 1, pp. 213-229.

Maxwell, D. and Watkins, B., (2003), Humanitarian information systems and emergencies in the greater horn of Africa: logical components and logical linkages, *Disasters*, Vol. 27, No. 1, pp. 72-90.

Oloruntoba, R., (2005), A wave of destruction and the waves of relief: issues, challenges and strategies, *Disaster Prevention and Management: An International Journal*, Vol. 14, No. 4, pp. 505-521,

Perry, M., (2007) Natural disaster management planning, *International Journal of Physical Distribution & Logistics Management*, Vol. 37, No. 5, pp. 409-433.

Pettit, S.J. and Beresford, A.K.C., (2006), Emergency relief logistics: an evaluation of military, non-military, and composite response models, *International Journal of Logistics: Research and Applications*, Vol. 8, No. 4, pp. 313-331.

Rietjens, S.J.H., (2006) Civil-Military cooperation in response to a complex emergency: Just another drill? University of Twente: Twente, The Netherlands.

Reitjens, S.J.H., Voordijk, H. and De Boer, S.J., (2007), Co-ordinating humanitarian operations in peace support missions, *Disaster Prevention and Management*, Vol. 16, No. 1, pp. 56-69.

Rollins, J.W., (2001) Civil-Military Cooperation (CIMIC) in crisis response operations: The implications for NATO, *International Peacekeeping*, Vol. 8, No. 1, pp. 122-129.

Safran, P. (2003), Asian Development Bank, (2003), A Strategic Approach for Disaster and Emergency Assistance, 5th Asian Disaster Reduction Centre International Meeting and 2nd UN-ISDR Asian Meeting, 15-17 January, 2003, Kobe, Japan.

Shemella, P., (2006), Interagency Coordination: The other side of CIMIC, *Small Wars and Insurgencies*, Vol. 17, No. 4, pp. 449-457.

Thomas, A., (2003), Why logistics? *Forced Migration Review*, Vol. 18, p. 4.

United Nations, (2008), United Nations Civil-Military Coordination Officer Field Handbook. Version E1.1, *UN Office for the Coordination of Humanitarian Affairs (OCHA) and Humanitarian Aid Department of the European Commission (DG ECHO): Civil-Military Coordination Section*: Geneva.

Van Wassenhove, L.N., (2006), Humanitarian aid logistics: Supply chain management in high gear, *Journal of Operational Research Society*, Vol. 57, No. 5, pp. 475-489.

Williams, G.H., (2005), *Engineering Peace: The military role in post conflict reconstruction*, Washington, United States Institute of Peace.

Zhang, D., Zhou, L. and Nunamaker, J., (2002), A knowledge management framework for the support of decision making in humanitarian assistance/disaster relief, *Knowledge and Information Systems*, Vol. 4. Pp. 370-385.

A FRAMEWORK FOR SUGGESTING LOGISTICS PARTNERS FOR THE VIRTUAL ORGANIZATION ENVIRONMENT

O Correia-Alves, J R Rabelo
Federal University of Santa Catarina Brazil

ABSTRACT:
This paper presents current results of an ongoing research on a novel model for the selection of the most adequate logistics providers to compose virtual organizations (vo). It includes a performance measurement model and a supporting methodology that considers the intrinsic dynamics, autonomy and temporality of a vo, involving both intra and inter-organizational indicators at operational and strategic levels. The model is flexible in terms of allowing indicators's weights relaxation (via ahp method) and being adapted according to the organizations' governance model.

1 INTRODUCTION

Globalization has demanded an increasing efficiency from expansion of logistics service providers. This requires a more careful and more agile selection of them to attend variable customers' needs from all over the world. The cleverer this selection is done the greater visibility, improved customer service, better planning and cost savings will be supported (Mentzer and Konrad 1991). When companies work in volatile strategic networks as *Virtual Organization* (VO), the difficult to select the most appropriate logistic providers is even higher.

Part of the difficulty is due to the intrinsic nature of a VO. A VO is represented by a logical group of autonomous, heterogeneous and geographically dispersed organizations that is dynamically created to attend to business opportunities (Mowshowitz 1997; Katzy and Obozinski 1999; Camarinha-Matos and Afsarmanesh 2005), sharing costs, benefits and risks, acting as it was one single enterprise (Sandberg 2007; Camarinha-Matos and Afsarmanesh 2008). After finishing all legal duties the logical arrangement is dismantled. In a VO, differently from traditional supply chains, logistics providers (responsible for handling material and cargo transportation) are usually not known in advance, as this depends on the business, on the client, on the country or region's regulations, etc. Therefore, the collaboration among involved *industrial* partners (who produces some part of the good) and logistic providers are very much important to enhance in order to match temporal and quality requirements of the business opportunity as well as to differentiate in the market as long as they create value in this chain (Esper and Williams 2003; Rafele 2004; Whipple and Russell 2007; Skjoett-Larsen 2003).

Considering this vision of a more tight collaboration, logistics providers are treated in this work as logistics *partners* (LP) and a business opportunity is treated as a *collaboration* opportunity (CO). Most of the works found out in the literature have addressed this general problem, often naming it as *partner's search and selection*. However, they have focused on how to select *industrial* partners (IP), but not the LPs that will link them. As such, a VO cannot be indeed formed. Besides that, current works on logistics in VOs mostly covers performance indicators that only cover the operational level and not the strategic level too. Yet, they do not consider other relevant dimensions when autonomous and collaborative companies do business together, such as governance and trust. Finally, the large majority of the works try to apply fully automated approaches when selecting partners, an approach which seems unrealistic regarding the complexity and particularities of a VO scenario, and that prevents involved companies' managers from putting in practice their experience.

This paper proposes a novel model that complements other contributions, with the aim of supporting the suggestion of the most adequate LPs to compose a VO, integrated to a comprehensive performance evaluation model, assisting managers in the final selection. It corresponds to an ongoing, qualitative, applied and partially exploratory work.

This paper is organized as following: chapter 1 introduced the problem. Chapter 2 stresses the problem of LP selection and presents a brief literature overview about it. Chapter 3 presents the proposed model. Chapter 4 described the underlying performance evaluation model. Chapter 5 provides some preliminary conclusions about the work.

2 LOGISTIC NETWORK PROBLEM

Collaborative Network Organizations (CNO) embraces several types of manifestations, where VO is one of them. A key aspect when considering VOs is that all of its members come from another type of CNO, which is the so-called Virtual organization Breeding Environment (VBE). A VBE is a long-term alliance of (mono or multi-sector) companies whose ultimate goal is to be the basis for the creation of VOs. Likely VOs, VBE members are composed of autonomous, heterogeneous and geographically dispersed companies. Regarding that they share principles (such as trust building and governance) and working methods (such as information sharing and minimum IT tools and platform), the creation of VOs from a VBE becomes much faster, more effective and less complex to manage (Rabelo, Baldo et al. 2004; Afsarmanesh and Camarinha-Matos 2005).

A typical VO is generally composed of LPs and IPs, creating a logistics network, as illustrated in Figure 1.

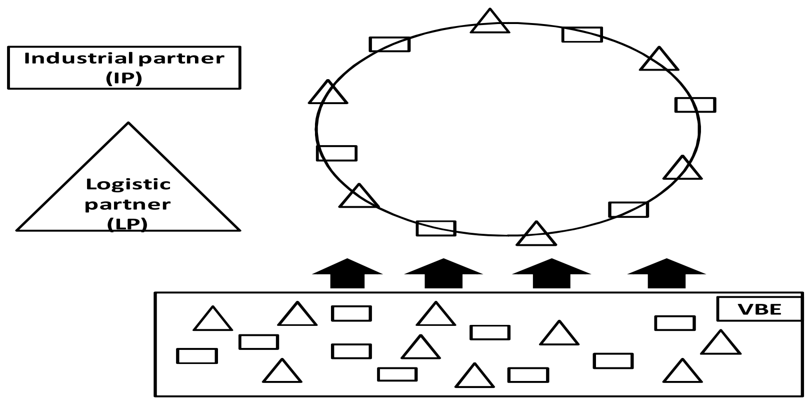


Figure 1: VO composed of LPs and IPs

A VO needs some steps to be created. A reference process for VO creation have been proposed in (Camarinha-Matos, Silveri et al. 2005) and consists of seven steps. Adopting a performance measurement approach, in (Baldo, Rabelo et al. 2008b) partners' search and selection step is extended introducing key performance indicators (KPI) as a first task to be set up to filter IPs. This paper follows the same approach, adapting it to LPs and restricting the model to the suggestion stage (Figure 2).

The VO creation is a complex task because LPs will work collaboratively in a VO and their selection should consider particular aspects of a VO and VBE, such as:

- The environment is dynamic, LPs can be identified after knowing the CO in details;
- A repeated CO will be rarely composed of the same set of VBE members;
- VO's LPs and IPs not necessarily will have worked together in some previous CO;
- COs are usually unique or one-of-a-kind;
- KPI (key performance indicators) and/or their weights vary from one CO to another;
- LPs usually have different information system, semantics and performance measures;
- The final handshake among IPs and LPs should be carried out as fast as possible;
- Each VBE has its particular governance model.

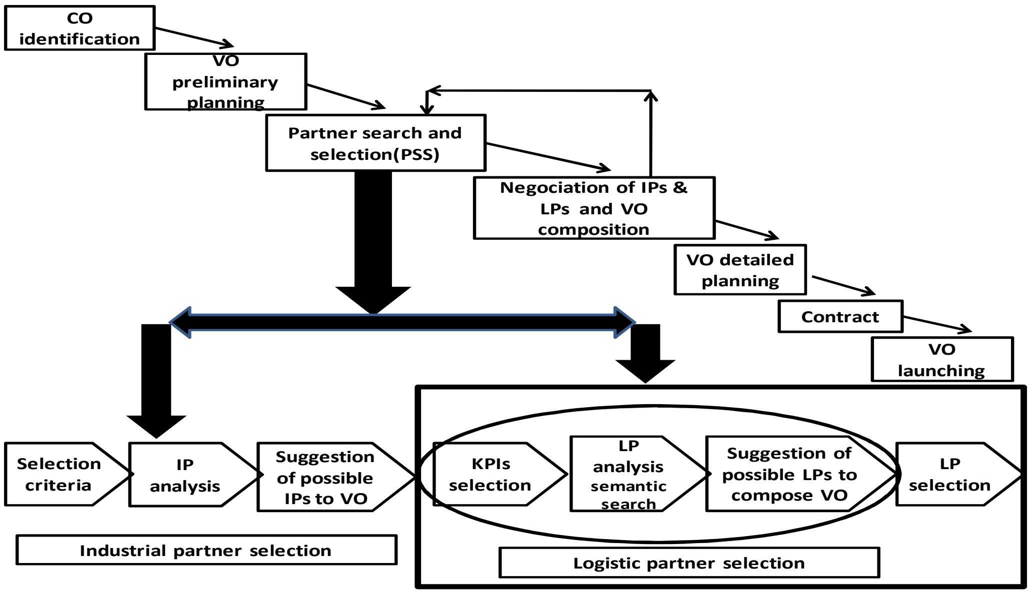


Figure 2: Extended framework for the VO creation

A literature survey about this showed that there are several approaches based on performance measurement and KPIs for evaluating companies (Seifert 2009). However, quite few of them address the problem of KPI models for LPs in VOs. For example, in (Westphal, Thoben et al. 2007) a generic methodology based on balanced Scorecard (BSC) indicators is proposed, but without any support for governance and trust issues, for example. The methodology proposed by (Bititci, Mendibil et al. 2005) calculates the level of collaboration and selects the partners to compose OVs but only based on two attributes: trust and collaboration. In (Sarkis, Talluri et al. 2007) the complexity of structuring a methodology for VO partners' selection is identified and a hierarchical methodology based on MADM (multiple attribute decision making) is proposed. However this work has focused only on intra-organizational performance indicators.

3 PROPOSED METHODOLOGY

In order to tackle this issue of suggesting adequate LPs for a given VO a methodology is proposed (Figure 3). Two important assumptions are considered. The first one is that all LPs are members of a VBE. The second one is that there is a global coordinator of the process, which is called VO Coordinator in the literature. An additional role is taken by a logistic specialist, who permanently audits the LPs' KPI values.

A. CO identification

In this first methodology stage the CO is verified in order to identify the logistics itineraries that have to be carried out. A CO, besides other information, is composed of the following logistics-related data:

- Place of origin (e.g. Paris);
- Place of destination (e.g. Chicago);
- Departure Date: date that the cargo should be loaded;
- Delivery Date: date that the cargo should be delivered to the end user;
- Service Modal: requested modal may involve different options (e.g.plane or ship);
- Cargo Type: cargo to be transported (e.g. parts, wood);
- Quantity: the amount (e.g. in tons) to be transported;
- CO itinerary: the list of itineraries (including the whole path and intermediate nodes) (e.g.: itinerary_1: Paris-Amsterdam; itinerary_2: Amsterdam-New York; itinerary_3: New York-Chicago);
- Technical skills: the requested LPs' technical competences and technical description of how and what should be shipped (e.g. see section B).
- Level of Collaboration (LC): minimum requested value for the given CO (e.g. see section D).

This set of information was based on a VO information reference model (Oliveira, Camarinha-Matos et al. 2007) and extended for this work.

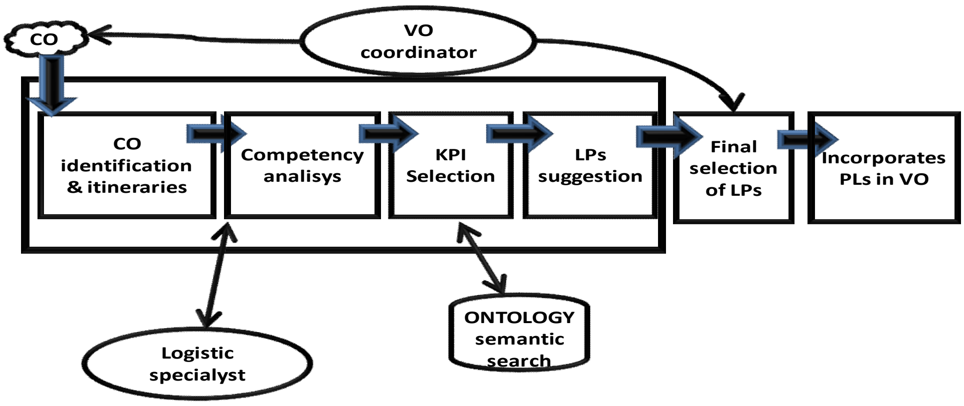


Figure 3: LP selection steps

B. LP competency skills analysis

In a first round of analysis the methodology checks the technical LP's competences against to every single CO itinerary. If a given LP is pre-selected then it is moved to a suggested list for further VO manager decision. After an analysis on the logistics discipline (Gunasekaran, Patel et al. 2001), seven attributes were elicited to represent LP competences:

- geographic coverage at source: (e.g. Amsterdam area);
- geographic coverage at the destination: (e.g. Chicago area);
- transportation of different type of loads: (e.g. oil, gas);
- modal options: (e.g. train, truck, plane);
- realization of consolidated shipments; (e.g. if the LP does the load consolidation before the shipment, meaning low cost of transportation);
- response time: (e.g. 3 days);
- cost: cost e.g. per ton;

The formal competency skills analysis is performed using the set theory. Two sets are considered: *R* and *M*. *R* represents the whole set of specific CO requirements *(R={1,…,r}).* *M* represents the set of LP's competencies *(M={1,..,m}),* which are expressed in KPI terms. The problem is to find a match between *R* and *M*, which will then define the pre-selected PLs for the given CO (Figure 4). This is provided by the function *G(i,j),* which represents the intersection of *R* and *M* sets:

$$G(i,j) = | R_i \cap M_j |, \quad \forall i \in R \quad \forall j \in M \qquad (1)$$

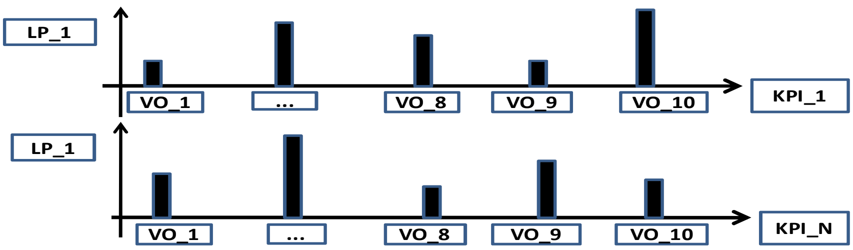
C. Identification and selection of KPIs

This third step of the methodology aims at selecting the most appropriate KPIs that will be applied over every CO's itinerary to filter the pre-selected LPs. This process is aided by an ontology, which considers and links the semantic of the CO' attributes with the developed KPI model. An ontology is used to provide a formal knowledge representation that can be used and reused to facilitate understanding of all involved concepts and relationships between them in a specific domain (Berners-Lee, Hendler et al. 2001). The developed KPI model comprises fifteen KPIs (see section D). More than one KPI can be applied to evaluate a given CO itinerary. LPs will be selected after this set of KPI evaluation. This strategy has been inspired from (Baldo, Rabelo et al. 2008b).

With the list of KPIs and LPs that were selected in the previous phases, the methodology determines the level of collaboration (LC) of each pre-selected LP for each itinerary. The LP to be finally suggested is the one with the highest LC value or with the highest coefficient of regression (see section D). VO coordinators evaluate the suggested list and assign one LP to the given itinerary and then this LP becomes member of the VO. The method repeats until the end of the CO itineraries.

D. Level of collaboration

The final decision about which LPs will compose a VO is determined by a last filter, which is LC. LC is a value calculated for each selected LP that was selected by the competence analysis. It is represented by a vector of collaboration (VC), which is formed by the historical collaboration (histogram) of each pre-selected LP in past VOs (Figure 4). It is composed of fifteen positions/KPIs, where each position is calculated multiplying the average of the historical values of each KPI by its respective weight minus the standard deviation for each KPI. The determination of the LC is applied to all LPs, as follows:



Vector_Collab_LP1= VC_PL1
VC_PL1=V[AA_KPI_1*W.kpi1 - S1, AA_KPI_2*W.kpi2 - S2, ..., AA_KPI_N*WA.kpin - Sn] **(2)**

AA_KPI_1 = represents the arithmetic average of the last N values of KPI_1
W.kpin = represents the weight of each KPI assigned by the method AHP
Sn = represents the standard deviation of KPIn for PL1

Level_collaboration_LP_1 = LC_LP1
LC_LP1 = ((AA_KPI_1*W.kpi1 - S_1) + (AA_KPI_2*W.kpi2 – S_2)+ ... + (AA_KPI_N*W.kpin - S_n)) **(3)**

Figure 4: Value of KPIs and historical metrics on LPs

- *Get past KPI values (from the VBE) from each pre-selected LP associated to their previous VOs;*
- *Determine the time horizon to be applied upon the LPs. Depending on the OV or the VBE policy, this can vary from a number of past OVs (e.g. the last ten participations) or period of time (e.g. the participation in the last two years);*
- *Calculates VC, where each vector field is the arithmetic average of the last values multiplied by the respective KPI's weight minus the standard deviation for each KPI. The weight is represented by the variable W.idn, and it is calculated using the AHP method (explained later);*
- *Determine total LC for each LP by the sum of the indices of the respective KPI VCs;*
- *Determine the straight line coefficient for the range of last n LC values for each LP, using the regression theory and the minimum quadratic method. (See Figure 5);*
- *Suggests the PL for each CO's itinerary according to the highest LC and/or the positive coefficient of regression of the straight line. The positive coefficient means that, historically, after each VO the KPIs values of a LP are increasing.*

The formula for VC and LC calculation is given by:

*VC(i,j,k)=(AA_KPI(i,j,k)*W(i,j,k))-S(i,j,k)* *(4)*

where:
i = number of KPIs;
j = number of LPs per itinerary;
k = number of itineraries within a CO;
AA_KPI = arithmetic average of historical values of the KPI i, referring to PL j, which is associated with the itinerary k;
W(i,j,k) = weight assigned to KPI by AHP;
S(i,j,k) = standard deviation of KPI i, LP j, and itinerary k;

$$LC(j,k) = \sum_{i=1}^{15} VC(i,j,k) \qquad (5)$$

where:
VC (i,j,k) = collaboration vector from KPI i to partner j, related to itinerary k;
LC (j,k) = level of collaboration of the PL j to itinerary k;
LC_a(j,k) = represents the level of collaboration of the PL j to itinerary k with the coefficient of regression;
LC (K) = [Max(LC(j,k)) or Max(LC_a(j,k))] *(6)*
where:
LC(k):represents the greatest value for the LC or for the LC with the highest coefficient of regression to itinerary k.

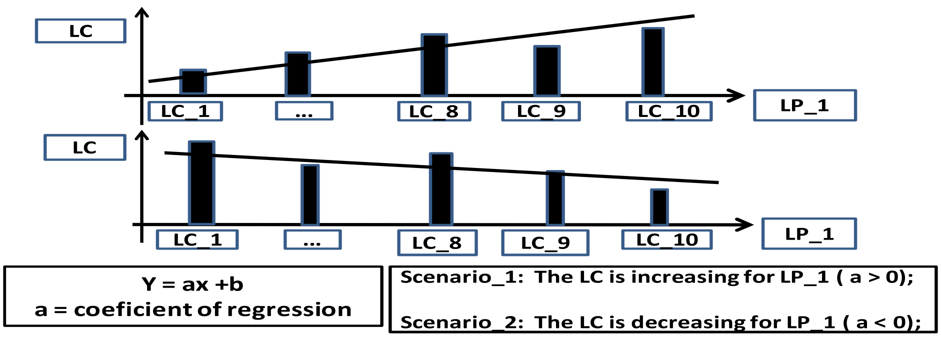


Figure 5: Linear regression analysis for LC

4 KPI MODEL

A crucial element in the proposed methodology is the KPI model. Regarding this, two general requirements were necessary to cope with. Firstly, the set of KPIs should consider both intra and inter organizational perspectives. Secondly, they should consider indicators at strategic level. After a literature review, several KPI models were found out (e.g. (Saiz, Bas et al. 2007; Westphal, Thoben et al. 2007; Seifert, Wiesner et al. 2008; Kim and Kim 2009)). However, none of them were neither comprehensive enough to cope with those requirements nor were devoted to logistics in dynamic alliances (e.g. VOs). Each KPI is seen as a strategic dimension, which is divided into a subset of individual and operational/lower level performance indicators (PIs). When computed as a whole, they provide the value of the KPI itself. For example, KPI Cost Control is calculated considering the PIs cost of warehousing, reverse cost and labor cost.

The devised KPI model has considered existing models (e.g. SCOR (Supply-Chain Council 2006)) and it was based on a literature overview. It is composed of 15 KPIs (Figure 6):

- ROE (return-on-equity): The amount of net income returned as a percentage of shareholders equity;
- Cash flow: focusing on the cash being generated related to how much is being generated and the safety net it provides to the LP;
- Cost Control: controls the cost reduction of LPs;
- Customer satisfaction: measures the customer perception related to delivered services;
- Susceptibility: measures the elapsed time between customer purchase order and product(s) delivery;
- Commitment: measures the level of commitment between the LPs;
- Collaboration: measures the LPs level of collaboration;
- IT maturity: measures if the LP’s IT objectives are aligned to its business strategies;
- Governance: measures how is code of conduct (ethical) and cultural issues of LPs;
- Flexibility: measures the LP flexibility level to be adapted to changes occurred at VO operation phase;
- Environmental performance: measures how the LP is compliant with environmental best practices;

- Availability: measures the level of LP availability;
- Effectiveness: measures if resources (e.g. labor) are properly allocated;
- Trust: measures the level of trust between the LPs;
- Communication: measure the level of effective communication among LPs' members.

The methodology applies the AHP method to assign weights to the fifteen KPIs. AHP was proposed in (Saaty 1990) to solve multiple criteria problems in a hierarchical structure. In AHP, criteria related to the goal are distributed at lower levels from the top of the KPI weight structure. The VC calculation uses this hierarchical structure to distribute the weights (the degree of importance) of KPIs and hence to suggest the most suitable LPs. All KPIs receives a weight. By default, the methodology assigns the higher weights to KPIs with a semantics matching with the CO, whereas lower weights are assigned to those without matching. The VO coordinator is in charge of assignment weights to KPIs.

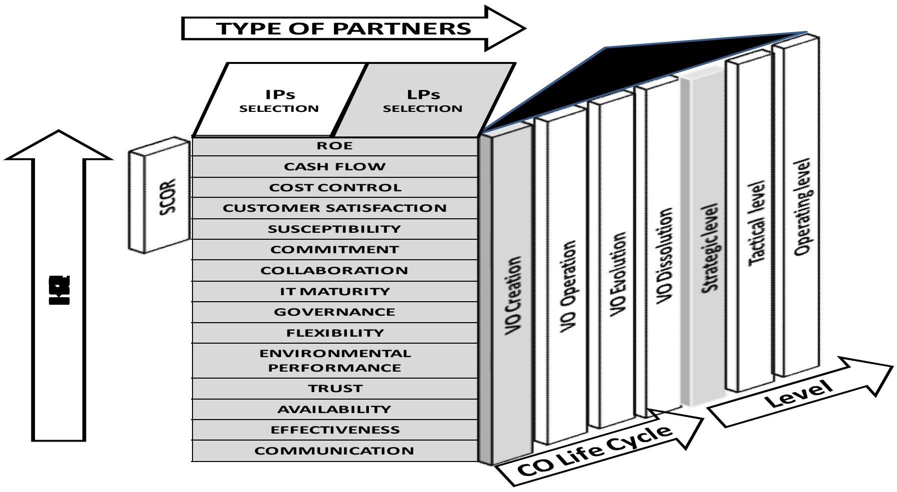


Figure 6: Developed KPI model

5 CONCLUSIONS

This paper has presented a novel model for supporting the selection of logistics partners to compose a virtual organization. It corresponds to an ongoing and essentially exploratory and qualitative work. It copes with to the intrinsic dynamics, temporality and autonomy of virtual organizations, whose partners (including logistics ones) can only be identified when the usually unique business opportunity is gathered from the market. Therefore, it is of extreme importance to not only make this process faster but also with more quality and confidence. As a contribution to this problem, a model and supporting methodology were proposed to assists the so-called virtual organization managers in deciding for the most adequate logistics partners for the whole value chain.

A new performance model has been also presented and it is devoted to cope with the singularities of virtual organizations. It is composed of 15 KPIs and it is used to compare companies' competences, regarding that their weights of importance can be flexibly assigned (applying AHP method). A formal ontology to establish the relation among requirements, KPIs and competences was specially conceived so mitigating semantic problems. After all, the set of logistics partners are selected based on their level of collaboration, also considering their past performance. So far the model has been only verified in a controlled environment and close to a very small group of logistics operators in the form of a general questionnaire. Next main steps will go for the implementation of the whole model and methodology as a decision support software prototype and testing it in near real scenarios.

REFERENCES

Afsarmanesh, H. and L. M. Camarinha-Matos (2005). A Framework for Management of VO Breeding Environments. Sixth IFIP Working Conf. on VEs, Valencia, Spain, Springer.

Baldo, F., R. Rabelo, et al. (2008b). Modeling Performance Indicators' Selection Process for VO partners' Suggestion. 8th IFIP International Conference on Information Technology for Balanced Automation Systems, Porto, Portugal, Springer.

Berners-Lee, T., J. Hendler, et al. (2001). "The semantic Web." Scientific American **284**(5): 28-37.

Bititci, U. S., K. Mendibil, et al. (2005). "Measuring and managing performance in extended enterprises." Int. J. of Operations & Production Management **25**(4): 333-353.

Camarinha-Matos, L. and H. Afsarmanesh (2008). Collaborative Networks: Reference Modeling, Springer.

Camarinha-Matos, L. M. and H. Afsarmanesh (2005). "Collaborative Networks: A New Scientific Discipline." J. of Intelligent Manufacturing **16**(4): 439-452.

Camarinha-Matos, L. M., I. Silveri, et al. (2005). Towards a Framework for Creation of Dynamic Virtual Organizations. Sixth IFIP Working Conf. on VEs, Valencia, Spain, Springer.

Esper, T. L. and L. R. Williams (2003). "The value of collaborative transportation management (CTM): its relationship to CPFR and information technology." Transport. Journal **42**(4): 55.

Gunasekaran, A., C. Patel, et al. (2001). "Performance measures and metrics in a supply chain environment." Int. J. of Operations and Production Management **21**(1/2): 71-87.

Katzy, B. R. and V. Obozinski (1999). Designing the virtual enterprise, Citeseer.

Kim, D. H. and C. Kim (2009). "A generic framework of performance measurement in networked enterprises." Int. Federation for infomation processing - IFP - PRO-VE 2009: 259-265.

Linacre, J. M. (2002). "Optimizing rating scale category effectiveness." J Appl Meas **3**(1): 85-106.

Mentzer, J. T. and B. P. Konrad (1991). "An efficiency/effectiveness approach to logistics performance analysis." Journal of Business Logistics **12**(1): 33-62.

Mowshowitz, A. (1997). "Virtual organization."

Oliveira, A. I., L. M. Camarinha-Matos, et al. (2007). D23.4b - VO Creation Support Services**:** 47.

Rabelo, R. J., F. Baldo, et al. (2004). Smart Configuration of Dinamic Virtual Enterprises. Fifth IFIP Working Conference on Virtual Enterprises, Toulouse, France.

Rafele, C. (2004). "Logistic service measurement: a reference framework." Journal of Manufacturing Technology Management **15**(3): 280-290.

Saaty, T. L. (1990). "How to make a decision: the analytic hierarchy process." European J. of Operational Research **48**(1): 9-26.

Saiz, J. J. A., A. O. Bas, et al. (2007). "Performance measurement system for enterprise networks." Int. J. of Productivity and Performance Management **56**(4): 305-334.

Sandberg, E. (2007). "Logistics collaboration in supply chains: practice vs. theory." The Int. J. of Logistics Management **18**(2): 274-293.

Sarkis, J., S. Talluri, et al. (2007). "A strategic model for agile virtual enterprise partner selection." International Journal of Operations & Production Management **27**(11): 1213-1234.

Seifert, M. (2009). "Collaboration formation in VOs by applying prospective PM."

Seifert, M., K. Wiesner, et al. (2008). Prospective performance measurement in virtual organizations, Springer US.

Skjoett-Larsen, T. T., C.; Andresen, C. (2003). "Supply chain collaboration Theoretical perspectives and empirical evidence." Int. J. of Physical Distribution and Logistics Management **Vol. 33**(6): 531-549.

Supply-Chain Council (2006). Supply Chain Operations Reference Model (SCOR Version 8.0).

Westphal, I., K. Thoben, et al. (2007). "Measuring collaboration performance in VOs." INT. FEDERATION FOR INFORMATION PROCESSING-PUBLICATIONS-IFIP **243**: 33.

Westphal, I., K. D. Thoben, et al. (2007). Measuring Collaboration Performance in VOs. Eighth IFIP Working Conf. on Virtual Enterprises, Guimarães, Portugal, Springer.

Whipple, J. M. and D. Russell (2007). "Building supply chain collaboration: a typology of collaborative approaches." Int. J. of Logistics Management **18**(2): 174.

SECTION 3 – SUPPLY CHAIN PEFORMANCE ASSESSMENT

REVISITING IMPORTANCE-PERFORMANCE ANALYSIS: FACTORS INFLUENCING PORT PERFORMANCE

Mengying Feng[1], Chandra Lalwani[2], John Mangan[3]
[1,2]The University of Hull, [3]The University of Newcastle

1. INTRODUCTION
Ports have become the core strategic resource to drive the regional economy within the context of globalization and the trade boom, as increasing international trade has caused increase of corresponding cargo container movements. Ports function as important economic catalysts for the regions they serve by handling international trade and providing employment to ports and their surrounding regions (Wood et al., 2002). In order to survive and be competitive, ports have to strive to meet the rapidly expanding needs of customers with efficient performance.

The American Association of Ports Authorities (AAPA) has an annual assessment of world ports ranking in terms of cargo volumes and container TEUs (Twenty-Foot Equivalent Units), which shows that port capabilities and performance vary across the world. Singapore port, for example, is proud of its port efficiency (Tongzon, 2007). Hongkong is well known as a free trade port. Shanghai is ranked number one in cargo volume (AAPA, 2009), benefiting from huge logistics demand from its large hinterlands. Rotterdam is known as the door to Europe resulting from its huge transhipment volume from/to the European continent. Port performance in this paper concerns port efficiency and this investigates underlying factors influencing different port performance from the perspective of port stakeholders.

2. LITERATURE REVIEW
2.1 Factors influencing port performance
Prior port studies focused on criteria of port competitiveness and port selection. Lirn et al. (2003) revealed that handling cost of containers, proximity to main navigation routes, proximity to import/export area, basic infrastructure conditions and existing feeder network are criteria for port selection. Tongzon and Heng (2005) proposed more key determinants of port competitiveness: port operations efficiency level, reliability, port selection preferences of carriers and shippers, the depth of the navigation channel, adaptability to the changing market environment, landside accessibility and product differentiation. Tongzon (2007) added that management quality, prices, quality of the service, exchange rates, government policies, political stability, investments in human and physical infrastructure would decide international port competitiveness. Yeo et al. (2008) revealed that port service, hinterland conditions, availability, convenience, regional centre and connectivity are the determining factors in Northeast Asia. Cullinane et al. (2005) analysed port competition between Shanghai and Ningbo and found that market-based reforms, the increasing globalization of China's economy, continuing economic development in the hinterland and China's entry into the WTO all contributed to the growing demand for port services. They also identified that logistical systems, growing cargo resources and leading liners such as Maersk and K-Line contributed to ports' competitiveness. Other researchers such as Mangan et al. (2002), and Wiegmans et al. (2008) have studied factors influencing port selection.

However, only a few empirical studies have been conducted on factors influencing port performance. Tongzon (1995) identified that location, frequency of ship calls, port charges, economic activity and terminal efficiency influence port throughput; container mix, work practices, crane efficiency, vessel size and cargo exchange influence efficiency. Tongzon (2007) found that demand conditions and supporting industries influence port performance. Chen and Zhang (2007), by employing the structure-conduct-performance (SCP) model, found that a combination of local monopoly and competitive cooperation influences port performance. Murphy et al. (1992) and Wiegmans et al. (2008) classified different groups of factors, but they did not prioritise them, measure them or compare them. Tongzon and Heng (2005) quantified the relationship between port ownership structure and port efficiency; however, they only quantified the factor of port ownership and failed to investigate other factors.

Briefly, as port competitiveness and port selection are closely related to port performance, the criteria of port competitiveness and factors influencing port selection are assumed to be factors influencing port performance. Although there are a large number of factors influencing port performance, previous studies did not classify, measure, prioritise or compare these factors. Failing to quantify factors does not provide sufficient information and allow port managers to identify the hierarchical order of importance of factors, so that the factors cannot be accorded a proper degree of importance. However, factors with different degrees of importance should be treated differently to avoid waste of resources and increase port efficiency due to limited port resources. Based on an extensive literature review, fifteen factors shown in Table 1 were selected for further investigation on factor classification and prioritisation.

	Factors	References
1	Availability of shipping services	Bichou and Gray (2004), Wiegmans (2008)
2	Price of shipping services	Gordon et al. (2005)
3	Port handling and other charges	Tongzon and Heng (2005), Arvis et al 2010
4	Feeder connections	Wiegmans (2008), Yeo et al., 2008
5	cheapest overall route	Arvis et al 2007, Bichou and Gray 2005
6	Speed of port cargo handling	Wiegmans et al. 2008, Gordon et al. 2005,
7	Congestion, risks and other risks	Wiegmans et al. 2008, Slack 1985, Talley 1996
8	Port/ terminal security and safety	Wiegmans et al. 2008, DFT
9	Technical infrastructure	Murphy 1992, McCalla1994
10	Proximity of the port	Lirn et al. 2004, Wiegsmans et al. 2008
11	Availability of skilled employees	Wu and Huang, 2008
12	Quality of landside transport links	Wiegsmans et al. 2008, Bichou and Gray 2004
13	Quality of logistics services	Bichou and Gray 2004, Slack 1985
14	Government supports	Arvis et al 2010, Wang & Oliver 2003
15	Depth of navigation channel	Wiegsmans et al. 2008, DFT

Table 1 Factor choice for empirical research

2.2 Importance-performance analysis

Importance-performance-analysis (IPA) provides a two-dimensional importance-performance grid with four quadrants. The values for each attribute are plotted against each other and displayed on the grid. Each attribute has a corresponding appropriate strategy. IPA is used as an analytical technique to identify improvement priorities. IPA offers advantages for evaluating customer acceptance of a service strategy and has been a popular tool for understanding customer satisfaction and prioritizing service quality improvement (Bacon 2003). IPA was originally introduced by Martilla and James (1977) who initiated the simple and easy-to-use technique to identify key factors for the development of an automobile marketing programme. They interpret the four quadrants into 'concentrate here', 'keep up the good work', 'low priority' and 'possible overkill', as shown in Figure 1. Self-stated importance and performance measures are employed for the matrix, which is named as traditional IPA in this study.

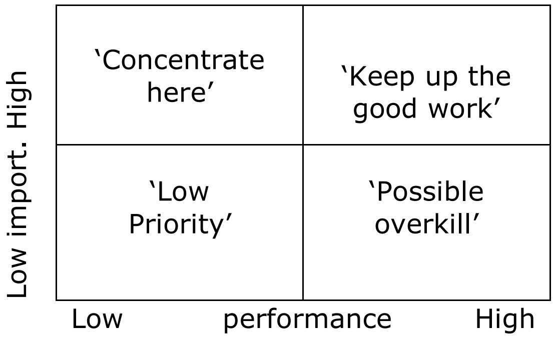


Figure 1 Traditional IPA grid
Source: Martilla and James (1977)

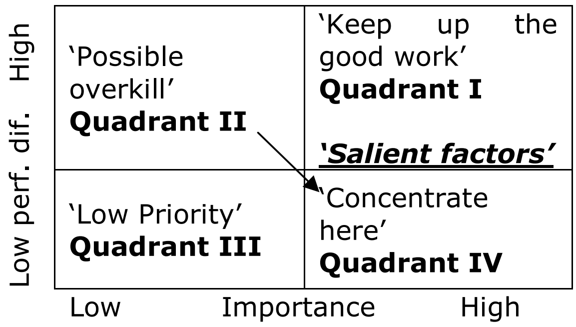


Figure 2 Revised IPA grid by gap analysis
Source: adapted from Mangan et al.2002, Deng et al. 2008

Apart from plotting items on a four-quadrant matrix, gap analysis is used to simultaneously consider importance and performance difference (Δperformance). Mangan et al. (2002) extended the traditional IPA model by integrating competitor's performance. This is different from traditional IPA, which only considers focal performance. The performance gap is measured by focal performance minus the competitor or bench marker's performance. It is treated as the room for the focal organisation to improve. The factors with high importance and a big performance difference are called 'salient factors' by Mangan et al. (2002). Based on their work, an importance-Δperformance model is developed as Figure 2 shows. In this model, each quadrant provides management information or service strategies. Factors in quadrant I (high importance and a big gap) are identified as 'salient' factors. They represent competition and are deemed major strengths. Their services should be maintained, leveraged, and heavily promoted (Lambert & Sharma, 1990). The organisation should 'keep up the good work' because they show the focal performance meets customers' satisfaction. Quadrant II represents low importance but a big gap, which means resources are over-allotted. The organisation can allocate a portion of the resources to the variables with high importance, for example Quadrant IV variables ('concentrate here') to achieve a more efficient flow and allocation of resources. Quadrant III represents low importance and a small gap. The organisation should consider stopping/decreasing the resources to these factors. Quadrant IV represents high importance but a small gap. Factors here are major weaknesses and should be top priority and targeted for immediate improvement efforts.

Deng et al. (2008) argue that the traditional IPA has two implicit assumptions: 1. Factor importance and factor performance are two independent variables. 2. The relationship between factor importance and factor performance is linear and symmetrical. They claim that the two assumptions are wrong, because: 1. The two variables are not independent. 2. The relationship of the two variables is not linear but causal (Matzler et al., 2003). This implies that the traditional IPA approach can be misleading (Bacon, 2003). In order to produce the factor structure of customer satisfaction, both explicit importance (self-stated importance) and implicit importance (importance correlated with performance) should be considered simultaneously.

Implicit importance	Low explicit importance	High explicit importance
High	**Excitement Factors (3)** High implicit importance Low explicit importance **II**	**Performance Factors (2)** (Important) High implicit importance High explicit importance **I**
Low	**Performance Factors (2)** (Unimportant) Low implicit importance Low explicit importance **III**	**Basic Factors (1)** Low implicit importance High explicit importance **IV**

Figure 3 The importance grid

Figure 3 presents a new model employing three-factor theory. The horizontal axis represents explicit importance while the vertical axis represents implicit importance. According to Matzler et al. (2003) and Deng et al. (2008), attributes in Quadrant IV (low implicit importance and high explicit importance) are basic factors; attributes in Quadrant I (high explicit importance and high implicit importance) and III (low explicit importance and low explicit importance) are performance factors; Attributes in Quadrant II (low explicit importance and high implicit importance) are excitement factors. These authors understand that basic factors are minimum requirements that cause dissatisfaction if not fulfilled but do not lead to customer satisfaction if fulfilled. They are basic requirements but with the utmost importance. Performance factors cause satisfaction or dissatisfaction depending on their performance level. They lead to satisfaction if fulfilled and lead to dissatisfaction otherwise. They are the second most important. Excitement factors can increase customer satisfaction if delivered but do not cause dissatisfaction if not delivered. They are the least important as they comprise augmented/enhanced services.

Ever since Martilla and James (1977) demonstrated the technique of IPA, IPA has attracted the interest of various academics and practitioners who widely use it for prioritising service improvements, such as operations and engineer services (Slack, 1994), education services (Ford et al., 1999), freight transportation (Mangan et al., 2002), human resources (Eskildsen and Kristensen, 2006) and tourism (Lai and To, 2010). The rich literature on IPA has indicated that IPA is a simple and effective technique that can assist practitioners to develop a new effective marketing strategy, to evaluate an existing strategy, to identify improvement priorities for service variables and to develop the business performance (Hansen and Bush, 1999). IPA has become a valuable and effective tool for strategic management and decision-making. This study employed IPA to identify key factors influencing port performance. To avoid confusion, traditional IPA (explicit importance against explicit importance) was not included. Instead, revised IPA by gap analysis was employed to identify salient factors and revised IPA by 3-factor theory was used to identify basic factors.

3. METHODOLOGY

3.1 Methods

A large-scale questionnaire survey was employed to collect empirical data to classify, quantify and prioritise the factors extracted from a literature review. For the survey construction, the survey consisted of three sections and in each section the same fifteen factors were rated. Section A sought opinions on the importance of the 15 factors. Section B concerned performance on the 15 factors for the selected ports. Section C sought evaluations of the 15 performance factors for other ports with which the respondents were most familiar. Factor importance and performance was measured using a five-point Likert Scale.

3.2 Samples

The Humber Estuary (UK) and Xiamen (China) were selected for the empirical research based on De Langen's (2003) four criteria of research location choice. Firstly, the two port regions are located in different social, economic, institutional and cultural contexts. Secondly, research in these two ports is feasible in terms of language and accessibility. Thirdly, the port activities are important for their regional economy. Fourthly, the ports are competitive. The questionnaire respondents were selected by a key informant approach. They were port professionals and experts from various port stakeholders who provided invaluable data and avoided respondent bias. The key port stakeholders included consignors/consignees, forwarders, carriers, port authorities/managers and other port stakeholders, based on the categorisation of port stakeholders by Murphy et al. (1992), and Bichou and Gray (2004). Ten questionnaires were piloted with PhD students, academics and port stakeholders in the port regions. Two hundred questionnaires were administered to the UK and 300 questionnaires were distributed to China, as China has more port stakeholders. Ninety-two valid responses from the UK (a response rate of 46%) and one hundred and sixty-two valid responses from China (a response rate of 54%) were received. The total response rate was 50.8%.

4. RESULTS

4.1 Descriptive statistics

Questionnaire data analyses were conducted with the Statistical Package for the Social Sciences (SPSS) version 17. Data analysis involved tests of normality, test of non-response bias, and selection of statistical techniques. No response bias was identified and the data distribution was normal. Parametric statistical techniques were therefore used. Table 2 presents the questionnaire results on means of factor importance, performance, implicit importance and other ports' performance. Separated by the grand mean of 3.86, the important factors are identified as shipping services, shipping prices, overall logistics cost, risks, logistics services, speed of cargo handling, risks, safety and port technical infrastructure in descending order.

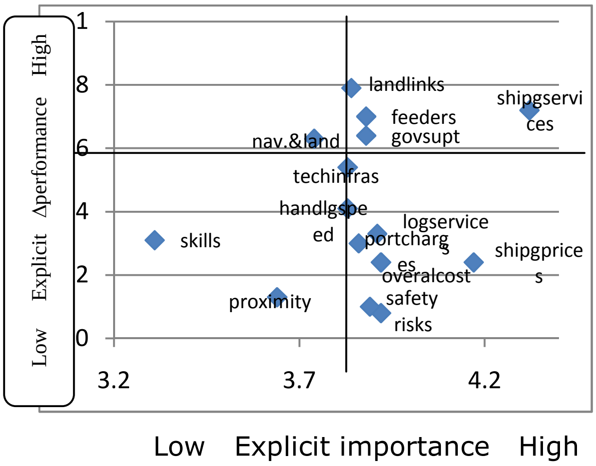
	D.O[1]	Imp.	D.O.	Perf.	D.O.	O'perf	D.O.	Imp[2]	D.O.	Imp.-perf.	D.O.	Perf. Dif.
1-shipservices	A1	4.32	B8	3.89	C1	4.25	7	.178	1	0.79	12	0.79
2-shippngprices	A2	4.17	B13	3.76	C4	4.17	8	.143	2	0.76	1	0.72
3-portcharges	A5	3.92	B6	3.59	C9	4.16	12	.103	5	0.71	4	0.70
4-feeders	A7	3.92	B9	3.59	C13	4.12	11	.112	14	0.70	14	0.64
5-overallcost	A13	3.91	B10	3.56	C12	4.04	13	.103	12	0.59	15	0.63
6-handlspeed	A8	3.89	B11	3.55	C6	4.02	6	.191	3	0.50	9	0.54
7-risks	A4	3.88	B7	3.53	C8	4.02	15	.021	4	0.41	6	0.41
8-safety	A14	3.88	B1	3.51	C15	4.00	5	.208	15	0.37	11	0.33
9-techinfras	A3	3.86	B4	3.48	C11	3.83	10	.130	7	0.37	13	0.31
10-proximity	A12	3.84	B2	3.42	C14	3.82	9	.143	6	0.22	3	0.30
11-skills	A6	3.83	B3	3.35	C10	3.67	2	.238	9	0.21	5	0.24
12-landsidelinks	A9	3.83	B15	3.27	C3	3.66	14	.103	13	0.12	2	0.24
13-logservices	A15	3.74	B5	3.23	C2	3.65	1	.257	10	0.10	10	0.13
14-govnmtsupt	A10	3.64	B12	3.22	C7	3.63	4	.229	8	-0.03	8	0.10
15-navig.	A11	3.31	B14	3.11	C5	3.45	3	.233	11	-0.21	7	0.08
Grand mean		3.86		3.49		3.90		0.16		0.37		0.41

(D.O[1]=descending order; A=importance; B=performance; C= other ports' performance; [2]=implicit importance)

Table 2 Mean descending order of factor importance and performance

4.2 Importance-performance analysis by gap analysis

Figure 4 shows the importance-(performance difference) analysis matrix using the explicit importance and performance difference between local ports and other ports the respondents referred to. In analysing the importance-performance matrix, it can be deduced that shipping services, government support and feeder services are salient factors, which are both important and have big performance difference from other ports. Landside links is very close to the boundary line and should be considered as a salient factor, which was validated by the confirmation of interviews. The focal ports' performances were actually rated much worse than other ports. Hence, urgent actions need taking for their improvement. Shipping prices, risks, safety, overall logistics cost and logistics services are in the quadrant of "keep up the good work". Port charges are on the boundary line between importance and unimportance; it is recommended to keep them at the current status from the cautious point of view. Navigation & land, and technical infrastructure have "low priority" for improvement. They were ranked with the least importance and much worse performance compared with other ports. Their poor performance is apparently not a problem, as they are relatively unimportant. Proximity, skills and speed are "overkill" or "excessive" factors, which are unimportant but have relatively good performance compared with other factors. Efforts on them may need transferring to other factors that need urgent actions, as they were over performing in relation to their importance, compared with other ports.



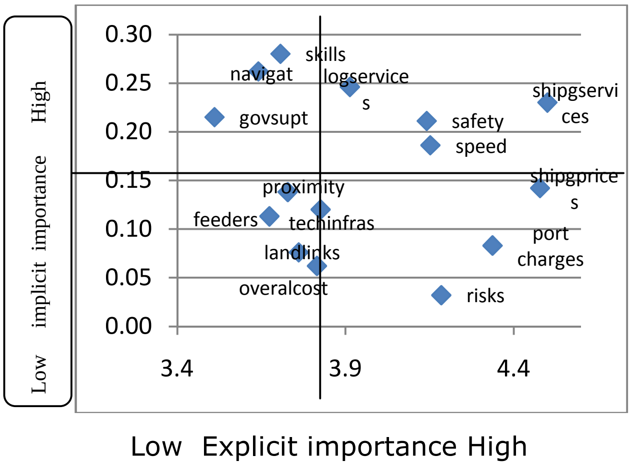


Fig. 4 Importance-Δ performance matrix Fig. 5 Basic/performance/excitement factors

It should be noted that this study shows "salient factors" are "not deemed major strengths" when the local performance is much worse than other ports' performance. This finding reflects an opposite case to Lambert & Sharma (1990) and Mangan et al. (2002). This implies that if the local port's performances are better than other ports, the salient factor services should be maintained and leveraged; however, if the local port's performances are worse than other ports, the salient factor services should be urgently improved. This finding enriches the literature.

4.3 Revised IPA by employing 3-factor theory and implicit weights

As reviewed earlier, revised IPA by employing 3-factor theory has been popularly used. This study adopted this technique to categorise factors and assist with service improvement strategy. To help in understanding the explicit and implicit importance, it is necessary to review the contents of IPA literature. Explicit importance refers to the self-stated mean score from questionnaire respondents, while implicit importance is based on the factor's correlation with an external criterion. Because there are no significant differences among the different methods to measure explicit importance and there are no significant differences among the different methods to measure implicit importance (Matzler et al., 2003), self-stated means were used as explicit importance and bivariate correlations of Spearman were employed to represent the implicit importance in this study. When the implicit and explicit importance weights were combined in a two dimensioned grid, a four quadrant grid was produced. Figure 5 presents the importance-performance grid integrating implicit importance.

Three factor groups were identified. Basic factors: shipping prices, risks and port charges were considered as basic factors. They are minimum and essential requirements of port services. They are totally expected and taken for granted as prerequisites. They have to be fulfilled. They are not important if their performance is satisfactory; however, they become important if their performance falls short. They are all service quality-related and should be taken most seriously with top priority of importance. This finding is not consistent with Song and Yeto (2004) who find that traditional factors such as location and port facilities rather than service quality are important. Performance factors: shipping services, speed, logistics services and safety were identified as highly important performance factors. Landside links, overall logistics cost, feeder services, proximity and port technical infrastructures were identified as low importance performance factors. Satisfaction increases linearly depending on the performance, which means higher performance will elicit higher customer satisfaction. Proximity has been recognised as very important for port performance by many researchers such as Lirn et al. (2003), de Langen (2003), Gordon et al. (2005). This study found that location is not so important as basic factors for port performance improvement. Excitement factors: government support, skills and navigation & land were considered as excitement factors. They are either highly unexpected or not expected to be delivered at such a high performance level, but they strongly enhance customer satisfaction. They make the port stand out from the competition if their performance is delivered.

When the IPA based on explicit importance against performance difference (Figure 4) is compared to the IPA based on explicit importance against implicitly derived importance (Figure 5), major differences occur. Different methods and techniques generate different factors. The findings confirm the claim of Matzler et al. (2003) that the importance-performance matrix is sensitive to the importance measure used. The salient factors identified in Figure 4 should be improved urgently considering other ports' performances. The different basic factors, performance factors and excitement factors identified in Figure 5 should be treated differently based on their different importance ranking.

5. CONCLUSIONS

Revised importance-performance analysis by gap analysis considering a competitor's performance provides salient factors for urgent improvement against competitors. The revised importance-performance analysis by employing three-factor theory is also practical for managerial recommendations, as it is based on implicitly derived importance, which is related to performance. Whenever possible, both IPA by gap analysis and IPA by 3-factor theory should be considered when setting a strategy of port improvement, as each technique has its own strengths: the former considers competitors' performance while the latter considers performance-related importance.

This is the first study to apply revised importance-performance analysis by employing three-factor theory in the port sector. This study found it crucial for managers to know which categories the factors belong to, so that they can decide whether performance should be increased or decreased. In order to formulate effective strategies, port managers need to include relative performance measures, either decreasing, increasing or keeping their performance. Table 3 summarises the managerial implications when relative performance is considered regarding the 15 questionnaire factors for port performance. As proposed by Matzler et al. (2003), port managers should fulfil all basic factors, be competitive with performance factors and stand out from the competition regarding excitement factors.

Factor group	Factors	Our performance	Other ports' performance	Implication
Basic factors (high explicit importance vs low implicit importance)	Shipping prices	poor	good	No market entry possible
	Port charges	poor	good	No market entry possible
	Risks	good	good	No advantage
Excitement factors (low explicit importance vs high implicit importance)	Navigation & land	poor	good	Competitive disadvantage
	Government support	poor	poor	Neglected opportunities
	Skills	good	good	Head-to-head competition
Performance Factors (high explicit importance vs high implicit importance; Low explicit importance vs low implicit importance)	Shipping services	good	good	Head-to-head competition
	Safety	good	good	Head-to-head competition
	Speed of handling	good	good	Head-to-head competition
	Logistics services	good	good	Head-to-head competition
	Feeder services	poor	good	Competitive disadvantage
	Technical infrastructure	good	good	Head-to-head competition
	Proximity	good	poor	Competitive advantage
	Landside links	poor	good	Competitive disadvantage
	Overall logistics cost	poor	poor	Neglected opportunities

Table 3 Strategies for port managers by employing 3-factor theory

REFERENCES

AAPA (2009), "World Port Ranking – 2009", in AAPA Web Accessibility initiative, accessed 12/09/2010 from http://aapa.files.cms-plus.com/Statistics

Arvis, J., Mustra, M.A., Ojala, L., Shepherd, B. and Saslavsky, D. (2010), *Connecting to Compete 2010 - Trade Logistics in the Global Economy: The Logistics Performance Index and Its Indicators*, Washington, DC: World Bank.

Bacon, D.R. (2003), "A comparison of approaches to Importance-Performance Analysis", *International Journal of Market Research,* Vol. 45, No.1, pp.55-71.

Bichou, K. and Gray, R. (2004), "A Logistics and Supply Chain Management Approach to Port Performance Measurement", *Maritime Policy & Management,* Vol. 31, No.1, pp. 47-67.

Chen, J. & Zhang, W. (2007), "Quantitative Analysis on Performance of Port Logistics Industry in China by SCP Theory." *Journal of Wuhan University of Technology* (Transport Science and Technology), Vol. 31, No.4: pp.71-74.

Cullinane, K., Teng, Y. and Wang, T. (2005), "Port competition between Shanghai and Ningbo", *Maritime Policy & Management,* Vol. 32, No.4, pp. 331-346.

De Langen, P. (2003), *The Performance of Seaport Clusters: A Framework to Analyse Cluster Performance and An Application to the Seaport Clusters of Durban, Rotterdam and the Lower Mississippi,* PhD thesis, Erasmus University, Rotterdam

Deng, W.J., Kuo, Y.F. and Chen, W.C. (2008), "Revised importance–performance analysis: three-factor theory and benchmarking", *The Service Industries Journal,* Vol. 28, No.1, pp. 37-51.

Ford, J.B., Joseph, M. and Joseph, B. (1999), "Importance-performance analysis as a strategic tool for service marketers: the case of service quality perceptions of business students in New Zealand and the USA", *The Journal of Services Marketing,* Vol. 13, No.2, pp. 171-186

Gordon, J.R.M., Lee, P.M. and Lucas, H.C. (2005), "A resource-based view of competitive advantage at the Port of Singapore", *The Journal of Strategic Information Systems,* Vol. 14, No.1, pp. 69-86.

Hansen, E. and Bush, R.J. (1999), "Understanding customer quality requirements: model and application", *Industrial Marketing Management,* Vol. 28, No.2, pp. 119-130.

Johns, N. (2001), "Importance-Performance Analysis Using the Profile Accumulation Technique", *The Service Industries Journal,* Vol. 21, No.3, pp. 49-63.

Lai, L.S.L. and To, W.M. (2010), "Importance-performance analysis for public management decision making", *Management Decision,* Vol. 48, No.2, pp. 277-295.

Lambert, D. and Sharma, A. (1990), "A customer-based competitive analysis for logistics decisions", *Physical Distribution and Logistics Management*, Vol. 20 No.1, pp.17-24.

Lirn, T., Thanopoulou, H.A. and Beresford, A.K.C. (2003), "Transhipment Port Selection and Decision-making Behaviour: Analysing the Taiwanese Case", *International Journal of Logistics: Research and Applications,* Vol. 6, No.4, pp. 229-244.
Mangan, J., Lalwani, C. and Gardner, B. (2002), "Modelling port/ferry choice in RoRo freight transportation", *International Journal of Transport Management,* Vol. 1, No.1, pp. 15-18.
Martilla, J. A. and James, J. C. (1977), "Importance-performance analysis", *Journal of Marketing,* Vol. 41, No.1, pp. 77-79.
Matzler, K., Sauerwein, E. and Heischmidt, K. A. (2003), "Importance-Performance Analysis Revisited: The Role of the Factor Structure of Customer Satisfaction", *The Service Industries Journal,* Vol. 23, No.2, pp. 112-129.
Murphy, P.R., Daley, J.M. and Dalenberg, D.R. (1992), "Port Selection Criteria: An Application of a Transportation", *Logistics and Transportation Review,* Vol. 28, No.3, pp. 237-255.
Slack, N. (1994), "The Importance-Performance Matrix as a Determinant of Improvement Priority", *International Journal of Operations & Production Management,* Vol. 14, No.5, pp. 59-75.
Song, D.w. and Yeo, K.t. (2004), "A Competitive Analysis of Chinese Container Ports Using the Analytic Hierarchy Process", *Maritime Economics and Logistics,* Vol. 6, No.1, pp. 34-52.
Tongzon, J. (1995), "Determinants of port performance and efficiency", *Transportation Research Part A:Policy and Practice,* Vol. 29, No.3, pp. 245-252.
Tongzon, J. (2007), "Determinants of Competitiveness in Logistics: Implications for the ASEAN Region", *Maritime Economics & Logistics,* Vol. 9, No.1, pp.67-84.
Tongzon, J. and Heng, W. (2005), "Port privatisation, efficiency and competitiveness: Some empirical evidence from container ports (terminals)", *Transportation Research Part A,* Vol. 39, No.5, pp. 405-424.
Wang, J. J. and Olivier, D. (2003), Port Governance and Port-City Relationships in China. Research Seminar: *Maritime Transport, Globalisation, Regional Integration and Territorial Development*
Wiegmans, B.W., Hoest, A.D. and Notteboom, T.E. (2008), "Port and terminal selection by deep-sea container operators", *Maritime Policy & Management,* Vol. 35, No.6, pp. p517-534.
Wood, D.F., Barone, A.P., Murphy, P.R. and Wardlow, D.L. (2002), *International Logistics,* (2nd edn.), London, American Management Association.
Wu, X. and Huang, M. (2008), "Analysis of Influencing Factors and Discussion on Developmental Strategy of Fujian Port Logistics", *Logistics Science and Techniques*, Vol. 2008, No.3, pp. 27-30.
Yap, W. and J. Lam (2006). "Competition dynamics between container ports in East Asia", *Transport Research Part A* 40: 35-51.
Yeo, G.t., Roe, M. and Dinwoodie, J. (2008), "Evaluating the competitiveness of container ports in Korea and China", *Transportation Research Part A,* Vol. 42, No.6, pp. 910-921.

CREATING A "BEST VALUE SUPPLY CHAIN"? EMPIRICAL EVIDENCE FROM THE GREEK FOOD CHAIN

C. Fotopoulos, M. Bourlakis, G. Maglaras

Professor Christos Fotopoulos, University of Ioannina, Department of Business Administration in Food and Agricultural Enterprises, Seferi 2, Agrinio, 30100, Greece. Tel: +30 26410 74123; E-mail: chfotopu@cc.uoi.gr

Professor Michael Bourlakis, Kent Business School, University of Kent, Canterbury, Kent, CT2 7PE, United Kingdom. Tel: +44 1227824491; E-mail: m.bourlakis@kent.ac.uk

George Maglaras, University of Ioannina, Department of Business Administration in Food & Agricultural Enterprises, Seferi 2, Agrinio, 30100, Greece. E-mail: geomag@cc.uoi.gr

ABSTRACT

The purpose of this study is to shed light on the differences in value outcomes within the Greek food chain by examining its key members and to illustrate which members are contributing towards value creation. Greek food companies evaluated the value outcomes of their supply chain based on key competitive priorities. The primary producers were found to have the worst value outcomes, the best outcomes were noted for the catering firms whilst the other members had strong results in specific value outcomes. Other findings show the chain members and their core activities responsible for value creation. They also suggest that the Greek food chain has still many characteristics of a traditional chain and many improvements are required to reach the "best value chain" status. At the end of the paper, the authors provide specific managerial implications emanating from this work.

Keywords: Traditional supply chain; Best value supply chain; Value creation; Value outcome; Food supply chain

INTRODUCTION

The concept of "value" is of paramount importance in marketing (Anderson & Narus, 1998; Lindgreen & Wynstra, 2005) and numerous studies have demonstrated the key benefits that it can generate. The relevant literature on value has been examined thoroughly by Lindgreen & Wynstra (2005) who illustrated the relevance of this concept not only to marketing but to purchasing and supply management too. A key aspect of their argument is value creation and delivery which relates strongly to supply chain management (SCM) and they recommend that future research can be directed towards examining "which actors in the chain create value, and which delivery process provides the best value for which customers" (Lindgreen & Wynstra, p. 742). The current paper focuses on the latter issue aiming to identify the actors of the Greek food supply chain that create value. Our view is that, in modern markets, value creation is not a dyadic issue that can be analysed by examining the buyer-supplier interface only. Hence, value creation should be analysed within the whole supply chain by examining all supply chain members responsible for value creation and for the final product offered to the consumer. The paper is organised as follows: the next section discusses the role and importance of SCM for the current research and introduces the concept of "best value supply chain management" where the empirical research is based. It is followed by a section on the methodological approach employed whilst another section analyses the key results. The managerial implications are discussed in the concluding section.

SUPPLY CHAIN MANAGEMENT (SCM) & BEST VALUE SCM

According to the Global Supply Chain Forum, SCM is defined as: "*the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders*" (Lambert & Cooper, 2000, p. 66). Therefore, the ability to deliver and create superior value is of large importance in the SCM field and it is this ability that provides supply chains with a competitive advantage in the marketplace (Li *et al.*, 2006; Hult *et al.*, 2006). Hence, a best value chain identifies the market structural shifts and modifies supply chain design and strategies to adapt to the changes in the environment. In addition, a traditional supply chain can transform itself to a best value chain only if it is capable of aligning the interests of all the chain members with their own (Lee, 2004). These supply chains with the above characteristics can be defined as best value supply chains (Ketchen & Hult, 2007). Hence, best value supply chains do not aim to improve only one supply chain characteristic but aim to maximise the total value added to the customer (Ketchen *et al.*, 2008) and to use supply chain as a means to create a competitive advantage and enhance firm performance. Therefore, these supply chains excel in their performance in relation to a set of competitive priorities and at the same time, they achieve superior success (and competitive advantage). Ketchen & Hult (2007) highlight speed, quality, cost and flexibility as these key competitive priorities within the best value supply chains. Specifically, speed is the ability to deliver products or services according to a set schedule whilst quality is focused on increasing product reliability and customer satisfaction. Flexibility is related with the ability of a chain to respond to the changing needs of the customers and cost refers to the creation of customer value through expenses reduction or benefits increase at the same cost level (Ketchen *et al.*, 2008). The value outcome (performance) of the chain considered in each of these four priorities could provide crucial results while the balancing of these four priorities can give to the chain the ability to achieve the highest level of total value added to the final consumer and the firms involved (Ketchen & Hult, 2007). Based on these notions, the four competitive priorities for the best value supply chains are restated below and are measured against key value outcomes (indicators) found in the relevant SCM performance literature. This approach was necessary as there is no relevant work in the appropriate "value" literature and, as mentioned earlier, the concept of value outcome is perceived as being similar to performance not only in this paper but even within the "value" literature (see for example, Lindgreen & Wynstra, 2005). Specifically, the four priorities are:

1. Cost with four value outcomes considered: production / operational/ raw materials cost, storage cost, delivery and distribution cost, financial cost (see Beamon, 1999).
2. Flexibility with two value outcomes considered: flexibility in extra volume orders and flexibility in delivering in extra point of sales (see Lohman *et al.*, 2004).
3. Speed / Ability to deliver in a timely manner with the following value outcomes considered: ability to deliver within the arranged lead time, ability to deliver timely at the arranged point of sale, ability to deliver timely the ordered type of product in terms of exact code and quality (Sanchez & Perez, 2005).
4. Product quality including the following value outcomes: raw material quality, quality of the firm's product, product conservation time, consistency in using a traceability system, storage and delivery conditions and quality of packaging for firm's products (Van der Vorst, 2005; Beamon, 1999).

We believe that following this approach, we will obtain important results about the value outcomes and the actual value delivered to the customers from that supply chain. In this work, we also evaluate the total value outcome (supply chain performance) in the Greek food supply chain. Our analysis includes the overall perception of a firm's total value outcome as well as the perceived market opinion about the firm's total value outcome as suggested by the same respondent in that firm. Ketchen *et al*. (2008) also stress that "best value chains" differ from the traditional ones in how they approach key issues such as agility, adaptability and alignment (3As) in their operations and note that these three As support the four competitive priorities. In addition, a strong value outcome in these four priorities is possible only if the chain members successfully coordinate strategic sourcing, logistics management, supply chain information systems and relationship management. Hence, organizations that develop best value supply chains enhance their value offering although these authors note that, currently, they are not familiar with any firms (and chains) that have achieved a "best value chain" status (Ketchen *et al*., 2008).

The current work will analyse the value creation process in the Greek food chain and will address the following research questions:

- In which value outcomes (and competitive priorities) does each food chain member excel or underperform?
- Which member of the Greek food chain is responsible for value creation?
- Can the Greek food chain become a best value supply chain?

METHODOLOGY

To address the above research questions, we used a number of quantitative and qualitative value outcomes and we evaluated them for every individual member of the Greek food chain separately as well as for the whole food chain. We conducted a survey facilitated by the use of a structured questionnaire. Anderson & Narus (1998) mention that this method is very appropriate for value evaluation and assessment studies. The questionnaire was divided in two sections. The first section included questions for the four competitive priorities (cost, flexibility, speed/ability to deliver in a timely manner, product quality) and two questions for the perception of the total value outcomes. The respondents were asked to evaluate their firms regarding these value outcomes. Cost was assessed as a percentage (%) of the total turnover of a firm whilst the other priorities and total value outcomes were evaluated against a seven point Likert-type scale (1=Very satisfying value outcome to 7= Very unsatisfying value outcome). The second section included demographics for the food chain members. The empirical work focused on four key sectors of the Greek food chain: dairy, fruit, meat and vegetables. These are the largest sectors in the Greek food chain in terms of total number of companies involved, employment and production at upstream level (both primary production and manufacturing) and these sectors share similar characteristics within the downstream level (wholesale, retail, catering) of that chain (ICAP, 2007a, b, c). In the empirical work, the following members / stages of the Greek food chain were examined: breeders / growers, manufacturers, wholesalers / importers / exporters, retailers and catering firms. The catering firms were found as key members only within the dairy and the meat chain (ICAP, 2007: a, b). Depending on the size of the firm, only the general manager or the owner was targeted. Data collection was carried out by a professional research agency by means of a Computer-Aided Personal Interviewing system (CAPI) and a total of 1,094 responses were analysed. In Table 1, the number of firms in every key food chain stage and their core product are illustrated.

Table 1: Examined Firms and Key Food Product Involved

Firm / Food product	Breeders/ Growers/	Manufacturers	Wholesale/ Importer/ Exporter	Retailer	Catering firms	Total
Dairy	35	75	70	49	26	*255*
Fruit	44	54	163	49	-	*310*
Meat	47	79	104	20	53	*303*
Vegetables	38	25	104	59	-	*226*
Total	*164*	*233*	*441*	*177*	*79*	***1094***

RESULTS / ANALYSIS

Profile of the respondent firms

Table 2 illustrates the profile of the respondent firms and their characteristics.

Table 2: Profile of the respondent firms

Type of firm (N=1094) (% of chain)	Breeders/ Growers		Manufacturers	Wholesaler / Importer / Exporter	Retailers	Catering firms
	N=164 (14.99%)		N=233 (21.30%)	N=441 (40.31%)	N=177 (16.18%)	N=79 (7.22%)
	Breeders/ Growers N=45	Growers' Associat. N=119				
No of employees (Mean)	Family-based	28	41	23	89	23
Turnover (more frequent responses in groups, euros)	40,000-50,000[a]	500,000-1,000,000	500,000-1,000,000	> 1,000,000	200,000-500,000	500,000-1,000,000
Size of warehouses (in sq.m.) (Mean)	N/A (61,6)[b]	3,587	2,488	1,747	610	1,085
No of trucks (Mean)	5[c]	4	6	6	3	5

[a] Annual income, [b] Farm size in hectares, [c] Number of agricultural trucks.

FOOD CHAIN VALUE OUTCOME

We obtained the average score for 17 value outcomes of the 4 competitive priorities. Table 3 provides average scores, means and standard deviations for these outcomes.

Table 3: Average value outcomes of the Greek food chain

Value outcome [a, b]	Score Mean (%) (SD) (N=1094)	Value outcome [c]	Score Mean (SD) (N=1094)
Producing / operational /raw material cost	46.05 (27.24)	Flexibility in extra volume orders	2.57 (1.58)
		Flexibility in delivering in extra points of sales	2.74 (1.78)
		Ability to deliver within the arranged lead time	1.87 (1.30)
		Ability to deliver timely at arranged point of sale	1.89 (1.45)
Storage cost	6.15 (7.39)	Ability to deliver timely the ordered type of product in terms of exact code and quality	1.75 (1.10)
		Raw material quality [d]	1.55 (0.75)
Delivery &distribution cost	7.13 (6.99)	Quality of the firm's product	2.20 (2.05)
		Product conservation time	3.56 (2.16)
		Consistency in using a traceability system	2.13 (1.68)
		Storage and delivery conditions	1.69 (1.09)
Financial cost	9.82 (11.74)	Quality of packaging for firm's products	2.93 (2.34)
		Firm's total value outcome	2.25 (1.03)
		Firm's total value outcome from the market point of view	2.23 (1.06)

[a] % of turnover, [b] Costs do not sum up to 100% of turnover as we measure different dimensions & could be other costs involved too [c] Seven points in Likert scale (lower values indicate higher value outcome), [d] Related to manufacturers only.

In terms of the cost priority, the producing / operational / raw material cost was the highest (46.05%). For the flexibility priority, the average outcomes were moderate whilst the speed priority / ability to deliver in a timely manner had higher scores for all three value outcomes (scores below 2). Food chain members evaluated very highly the raw material quality (1.55) whilst the quality of the firm's product was evaluated lower (2.20); the product conservation time had the worst value outcome score in the specific priority (3.56). Finally, the two average scores for the perception of the total value outcomes were similar (2.25 and 2.23 respectively) indicating a consensus of what is perceived at firm and chain level.

Differences in value outcomes between food chain members

Analysis of variance (ANOVA) was employed to determine whether any significant score differences were present between the chain members. ANOVA is a widely used statistical method for this kind of investigation and many examples can be found in the relevant literature (see Kahn *et al.,* 2006). Table 4 illustrates significant differences between food chain members for most value outcomes (12 out of 17).

Table 4: Differences in value outcomes between food chain members

Value outcome	Breeders / Growers Mean (SD) (N=164)	Manufa-cturers Mean(SD) (N=233)	Wholesalers / Importers / Exporters Mean(SD) (N=441)	Retailers Mean (SD) (N=177)	Catering firms Mean (SD) (N=79)	ANOVA *F-statistic* [c]
Delivery& distribution cost [a]	5.83 (6.75)	8.11 (6.95)	8.04 (7.26)	4.18 (5.18)	7.76 (7.42)	6.198
Financial cost [a]	11.45 (13.37)	12.28 (13.77)	9.70 (11.10)	4.91 (6.42)	9.65 (10.81)	5.235
Flexibility in extra volume orders [b]	3.12 (1.97)	2.50 (1.54)	2.45 (1.43)	2.63 (1.53)	2.18 (1.46)	7.202
Flexibility in delivering in extra points of sales [b]	3.28 (2.15)	2.57 (1.73)	2.46 (1.50)	3.40 (1.97)	2.20 (1.35)	15.697
Ability to deliver within arranged lead time [b]	2.05 (1.51)	1.67 (0.94)	1.90 (1.26)	2.15 (1.69)	1.34 (0.58)	7.826
Ability to deliver timely at arranged point of sale [b]	2.20 (1.76)	1.83 (1.39)	1.81 (1.26)	2.15 (1.79)	1.29 (0.54)	7.234
Ability to deliver timely ordered type of product in terms of exact code & quality [b]	1.97 (1.38)	1.62 (0.94)	1.79 (1.08)	1.78 (1.18)	1.34 (0.60)	5.371
Product conservation time [b]	3.74 (2.20)	3.11 (2.10)	3.31 (2.04)	3.84 (2.14)	5.27 (2.00)	18.552
Consistency in using traceability system [b]	2.35 (1.93)	1.86 (1.52)	2.04 (1.49)	2.51 (1.97)	2.16 (1.72)	4.826
Quality of packaging for firms' products [b]	2.97 (2.39)	1.89 (1.43)	2.93 (2.34)	4.01 (2.57)	3.52 (2.57)	23.974
Firm's total value outcome [b]	2.45 (1.10)	2.15 (0.95)	2.26 (0.98)	2.33 (1.21)	1.87 (0.74)	5.215
Firm's total value outcome from market point of view [b]	2.38 (1.13)	2.12 (1.02)	2.24 (1.07)	2.31 (1.11)	1.99 (0.84)	2.748

[a] % of turnover, [b] Seven points in Likert scale (lower values indicate higher value outcome), [c] $p < 0.05$

Regarding the cost priority, the food chain members expressed significantly different value outcomes in two out of the four items (delivery and distribution cost and financial cost). The delivery and distribution cost was higher for manufacturers, wholesalers / importers / exporters and catering firms and lower for retailers and breeders. This can be explained by the fact that breeders and growers don't take part in the product distribution. The financial cost was found to be significantly higher for manufacturers and breeders / growers and lower for retailers. This is due to the fact that growers and manufacturers have higher loan repayments than other chain members. The flexibility competitive priority received a low evaluation in Table 3. However, in Table 4, we have found differences in the flexibility value outcomes between chain members. The breeders / growers had the worst scores, probably due to the nature and characteristics of their products (i.e. seasonality in production). On the contrary, the catering firms, wholesalers / importers / exporters and manufacturers were more flexible. The catering firms had better results than every other chain member for three value outcomes in relation to the speed / ability to deliver priority and this is a unique and original finding. In terms of the product quality priority, the product conservation time was the value outcome that had the worst scores as indicated by every food chain member. This is not a surprising result as managing perishable food products is an extremely challenging task including managing conservation time. In terms of the total value outcomes, the catering firms returned a higher evaluation than every other food chain member.

Value outcome analysis between food chain members & the average food chain
We employed a T-test to show the differences in value outcomes produced by chain members in comparison to the average results for the whole food chain (Table 5). The results clearly show that the breeders / growers evaluated their value outcomes lower than the average of the chain. These members lacked flexibility and had the worst scores in relevant outcomes (flexibility in extra volume orders, 3.12 and flexibility in delivering in extra point of sales, 3.28) when compared to similar results obtained by other chain members (e.g. catering firms) and the average scores for the food chain. Breeders / growers do not seem to be able to respond in a timely manner (ability to deliver timely at the arranged point of sale, (2.20) and ability to deliver timely the ordered type of product in terms of exact code and quality, (1.97)) compared to other chain members and the average chain (1.89 and 1.75 respectively).

Table 5: Value outcome differences between chain members & average chain

Value outcome	Breeders/ Growers/ Mean (SD) N=164 *(T-test)*	Manufacturer Mean(SD) N=233 *(T-test)*	Wholesaler/ Importer/ Exporter Mean(SD) N=441 *(T-test)*	Retailer Mean (SD) N=177 *(T-test)*	Catering firms Mean (SD) N=79 *(T-test)*	Food chain Mean N=1094 *(T-test)*
Producing / operational / raw material cost [a]		52.19 *(2.869)*		40.08 *(-2.045)*		46.05
Storage cost [a]				4.49 *(-2.185)*		6.15
Delivery and distribution cost [a]				4.18 *(-5.151)*		7.13
Financial cost [a]				4.91 *(-6.751)*		9.82
Flexibility in extra volume orders [b]	3.12 *(3.597)*				2.18 *(-2.397)*	2.57
Flexibility delivering in	3.28 *(3.216)*		2.46 *(-3.853)*	3.40 *(4.460)*	2.20 *(-3.531)*	2.74

extra points of sales [b]						
Ability to deliver in arranged lead time [b]		1.67 *(-3.334)*		2.15 *(2.228)*	1.34 *(-8.168)*	1.87
Ability to deliver timely at arranged point of sale [b]	2.20 *(2.266)*				1.29 *(-9.954)*	1.89
Ability to deliver timely ordered product type & exact code & quality [b]	1.97 *(2.042)*	1.62 *(-2.085)*			1.34 *(-6.081)*	1.75
Product conservation time [b]		*3.11 (-3.285)*	3.31 *(-2.594)*		5.27 *(7.588)*	3.56
Consistency in using traceability system[b]		1.86 (-2.737)		2.51 (2.557)		2.13
Quality of packaging for firms' products [b]		*1.89 (-11.097)*		4.01 (5.572)	*3.52 (2.040)*	2.93
Firm's total value outcome [b]	2.45 (2.334)				1.87 (-4.522)	2.25
Firm's total value outcome from market viewpoint [b]					1.99 (-2.569)	2.23

[a] % of turnover, [b] Seven points Likert scale (lower values indicate higher value outcome), [c] p< 0,05.

The results also show that the food manufacturers enjoyed slightly better value outcomes than the average chain in many priorities. For example, that was the case for the priority of speed / ability to deliver in a timely manner. The wholesalers / importers / exporters were the largest group in our sample and this may justify the small difference found between their value outcomes and the average chain. Wholesalers / importers / exporters had slightly better scores in flexibility (flexibility in delivering in extra points of sales: 2.46 in comparison with the chain average: 2.74) and in product conservation time (3.31 in comparison with the chain average: 3.56). Managers from retailers perceived their operations as accumulating low costs. Specifically, their producing / operational / raw material cost is lower (40.08%) than the chain average cost (46.05%). Managers from catering firms noted value outcomes for their firms which were much better than any other member in some key competitive priorities.

CONCLUSIONS

The primary members (breeders / growers) are the weak link in the Greek food chain as poor results were evident for most value outcomes. The retailers enjoy strong results for many value outcomes of the cost priority whilst the manufacturers excel in three value outcomes of the product quality priority. The wholesalers / importers / exporters, which together with the manufacturers represent the middle part of the food chain, returned good results for many value outcomes. The above suggests that the middle part of the Greek food chain is performing satisfactorily in terms of both value creation (the manufacturers) and value delivery (the wholesalers / importers / exporters followed by retailers); however, this is not the case for the primary part of the chain that underperforms. The catering firms had the best results in numerous value outcomes and excelled in two competitive priorities: flexibility and speed / ability to deliver in a timely manner. The catering firms had also the best results in relation to total value outcome suggesting their key contribution in terms of value delivery in the Greek food chain. The above discussion has addressed succinctly the first two research questions. Regarding the third research question, it is clear that the Greek food chain is still closer to the traditional chain concept and many improvements are required to reach the status of a "best value chain". Future improvements could emanate by following the practices of the chain members which excel on specific value outcomes including the catering firms and the middle chain members. The latter suggestion will be of particular importance to managers, practitioners and industry professionals. For example, the results from the T-test analysis could be used as benchmark points and can guide companies towards achieving highest scores in specific business areas; some of those areas comprise the competitive priorities. Finally, every chain needs to create and deliver value to the final customer and our paper has demonstrated the value successes and failures related to specific members of the Greek food chain.

REFERENCES

Anderson, J.C., & Narus, J.A. (1998). Business marketing: Understand what customers value. *Harvard Business Review*, 76 (6), 53-65.

Beamon, B.M. (1999). Measuring supply chain performance. *International Journal of Operations and Production Management,* 19 (3), 275-292.

Hult, G.T.M., Ketchen, D.J., Cavusgil, T., & Calantone, R. (2006). Knowledge as a strategic resource in supply chains. *Journal of Operations Management,* 24, 458-475.

ICAP Hellas (2007a). *The Greek dairy sector*, ICAP Hellas, Athens.

ICAP Hellas (2007b). *The Greek meat sector*, ICAP Hellas, Athens.

ICAP Hellas (2007c). *The Greek canned fruit and vegetables sector*, ICAP Hellas, Athens.

Kahn, K., Maltz, E. & Mentzer, J. (2006). Demand collaboration: effects on knowledge creation, relationships, and supply chain performance. *Journal of Business Logistics*, 27 (2), 191-221.

Ketchen, D.J. & Hult, T.M.G. (2007). Bridging organization theory and supply chain management: the case of best value supply chains. *Journal of Operations Management*, 25, 573-580.

Ketchen, D.J., Rebarick, W., Hult, T.M.G., & Meyer, D. (2008). Best value supply chains: A key competitive weapon for the 21st century. *Business Horizons*, 51, 235-243.

Lambert, D. & Cooper, M. (2000). Issues in supply chain management. *Industrial Marketing Management*, 29, 65-83.

Lee, H.L. (2004). The triple A supply chain. *Harvard Business Review*, 83, 102-112.

Li, S., Ragu-Nathan, B., Ragu-Nathan, T.S., & Subba Rao, S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. *Omega*, 34, 107-124.

Lindgreen A., & Wynstra, F. (2005). Value in business markets: What do we know? Where are we going? *Industrial Marketing Management,* 34, 732-748.

Lohman, C., Fortuin, L. & Vouters, M. (2004). Designing a performance measurement system: A case study. *European Journal of Operational Research,* 156, 267-286.

Sanchez, A.M. & Perez, M.P. (2005). Supply chain flexibility and firm performance: A conceptual model and empirical study in the automotive industry, *International Journal of Operations and Production Management*, 25 (7), 681-700.

Van der Vorst, J.G.A.J. (2005). Performance measurement in agri-food supply chain networks. An overview. In Ondersteijn, C.J., Wijnands, J.H., Huirne, R.B. & Van Kooten, O., (Eds), *Quantifying the Agri-food Supply Chain*, (pp. 13-24) Berlin: Springer.

LINKING SUPPLY CHAIN OPERATIONS' PERFORMANCE TO THE COMPANY'S FINANCIAL STRATEGY: A CASE STUDY OF AN EGYPTIAN NATURAL BOTTLED WATER COMPANY

Elgazzar,S.H., Tipi,N.S., Hubbard, N.J. and Leach,D.Z.
Transport and Logistics Research Group, The University of Huddersfield, UK
Email:U0873719@hud.ac.uk

1. INTRODUCTION

Over the last decade, supply chain management has become a recognized strategic tool to ensure customer satisfaction (Chopra and Meindl, 2004). Strategic supply chain management improves the way processes are done and hence improves long-term performance (Harrison and Van Hoek, 2005). Evaluating the performance of supply chain (SC) operations can contribute to redesigning business goals and strategies through assessing the current SC operations' performance in order to identify core competence operations and those operations which need improvement.

Current performance measurement systems in supply chain management have many drawbacks, such as the lack of a connection with strategy and the failure to provide integration between financial and non financial measures (Chan and Qi, 2003; and Chan et al., 2006). Presutti jr. and Mawhinney (2007) stated that about 70 percent of a manufacturing firm's expenditures are on supply chain-related activities. Linking supply chain operations' performance to the company's overall financial strategy represents an opportunity for companies to gain competitive advantages and develop strategies to better manage SC operations' through linking such strategies to the focus areas for enhancing financial performance.

This paper aims to propose a method to link supply chain operations' performance to the priorities of the company's financial strategy. According to this method, the priorities of the supply chain performance measurement attributes are determined with respect to the priorities of the financial performance drivers. Supply chain operations' performance is measured based on the Supply Chain Operations Reference-Model (SCOR) standard performance metrics, while the company's financial performance priorities are determined using Du Pont ratio analysis. To link supply chain operations' performance to the financial performance priorities, the Fuzzy Analytical Hierarchy Processes (FAHP) technique is used.

To demonstrate the applicability of the proposed approach, a case study of an Egyptian Natural Bottled Water Company was conducted.

The remainder of this paper is organized as follows. In the next section a review of related literature is performed. In section 3, the research approach is discussed. Then, the framework for the proposed research method is illustrated in section 4. In section 5, a case study is presented and analyzed to demonstrate the applicability of the proposed method. Finally, conclusions are presented in section 6.

2. LITERATURE REVIEW

2.1. SCOR model:

The SCOR model was developed in 1996 by the Supply-Chain Council (SCC). This model is based on five core processes (plan, source, make, deliver, and return) and divided into three levels of process detail (top level, configuration level, and process element level). The model attempts to integrate the concepts of business process reengineering, benchmarking, process measurement, and best practice analysis which allows the upper management of a firm to make connections between strategies and measurements and to concentrate on key processes and measures that have a significant impact on the overall performance of a SC (Lockamy and McCormack, 2004; and Huang et al., 2005).

SCOR provides standard descriptions of supply chain processes that make up the SC and a process framework for defining relationships among these standard processes. It includes a set of benchmarking tools for performance and process evaluation. Using this model allows companies to select the right performance measures as it includes ten performance metrics to measure the performance of SC processes (perfect order fulfillment, order fulfillment cycle time, upside supply chain flexibility, upside supply chain adaptability, downside supply chain adaptability, supply chain management cost, cost of good sold, cash to cash cycle time, return on supply chain fixed assets; and return on working capital) which fall into five standard performance categories: reliability, responsiveness, flexibility, cost, and asset metrics. These ten performance metrics are designed to provide a view of overall SC performance at level 1 (top level) while the SCOR model levels 2 and 3 (configuration level and process element level) supporting metrics are keys to these ten level 1 metrics (Huan et al., 2004, and Hwang et al, 2008).

2.2. FAHP technique:

One of the most critical challenges facing decision makers in different industries and businesses is to determine the relative importance of the evaluation criteria with respect to the overall objective. The natural limitations of human capability to compare or to decide on more than two factors or alternatives makes the multi criteria decision-making process(MCDM) complex and challenging (Deng, 1999; and Abdul Moneim, 2008). Numerous MCDM analysis methods have been developed (such as SAW analysis model, TOPSIS method, and VIKOR method) to deal with decision or selection problems (Kuo et al., 2006).

One of the most widely used approaches for MCDM is the analytic hierarchy process (AHP) method (Mikhailov, 2003). In the AHP, first, the decision problem is structured in a hierarchy of different levels of elements, and then a pair-wise comparison matrix is used to determine the relative priorities of the decision elements (weights of the criteria). The pair-wise comparisons are accepted as linguistic evaluations or assessments expressing relative importance of pairs. Finally, the weights of each element in each hierarchical level are aggregated to the next level applying the principle of hierarchic composition (Mikhailov, 2004).

In most cases in real life, the available data and information are incomplete and the decision environment is uncertain and complex. In these cases, the classical AHP technique is not valid and the decision makers could be uncertain about their level of preferences (Kahraman et al., 2003). In recent years, several studies have been developed to handle this kind of uncertainty in preferences using fuzzy set theory and the application of fuzzy set theory to multiple criteria evaluation methods (Kuo et al., 2006; and Leung and Cao, 2000). Fuzzy set theory is a tool which can deal with this type of inexact data by assigning to each object a grade of membership ranging between zero and one (Kahraman et al, 2003). According to Kunadhamraks and Hanaoka (2008), in the Fuzzy AHP procedure, the pair-wise comparisons in the judgment matrix are fuzzy numbers that are modified by the designer’s emphasis. Preference weights among main-attributes, sub-attributes and indicators are obtained by using a questionnaire survey. The survey respondents are asked to rank the components of a given layer by giving interval judgments than fixed value judgments according to its comparative importance.

2.3. Combining the SCOR model and FAHP technique:

Despite all the advantages that SCOR model and FAHP technique have, there are some limitations regarding successful implementation of these approaches for measuring SC operations’ performance. A combination of both approaches allows some of their limitations to be overcome offering a better alternative for measuring SC operations’ performance.

Although FAHP appears to be an appropriate tool for analyzing complex multi-criteria decision-making problems, it doesn't specify relevant measures for measuring SC operations' performance. The inability to reach relevant performance measures and to define SC metrics can represent a barrier for successful implementation of the technique. The use of SCOR performance metrics allows the decision makers to deal with a limited number of critical measures to evaluate the supply chain performance (Theeranuphattana and Tang, 2008).

Huan et al., (2004) analyzed the weaknesses of the SCOR model. Their analysis illustrated that although SCOR provides ten performance metrics to measure overall supply chain performance, there is a debate about how these ten metrics can be used to derive a quantifiable supply chain performance measure. SC performance measures should be linked with strategies; which may need a quantitative tool to link SCOR metrics to SC strategies. Huan et al. illustrated how AHP can be applied with SCOR metrics to construct an overall objective function (overall supply chain efficiency) for network optimization. By using AHP measurement methodology managers can quantify – from their judgments – the weights of influence of SC strategy on individual performance measures.

Combining the SCOR model with the FAHP technique for measuring SC operations' performance can overcome some limitations of using each approach separately. Applying FAHP to the SCOR model, allows managers to determine the degree to which performance metrics contribute towards the success of a particular strategy.

2.4. Du Pont ratio analysis:

Literature on supply chain management assumes that high supply chain performance is associated with high-financial performance through managing costs, increasing revenues and improving asset utilization (Anderson et al., 1997).

One of the common financial measures to used measure an organization's financial performance is Du Pont analysis. Du Pont analysis is a financial ratio developed by F.Donaldson Brown to analyze the efficiency and profitability of the company. The analysis of the Du Pont ratio evaluates the areas of profitability and operating efficiency through assessing the performance of the components contributing to return-on-assets (ROA): revenue (sales), cost, and total assets. ROA measures how much profit a company generated compared to assets employed in the business. It consists of a profitability measure (net profit margin) and an efficiency measure (total assets turn over) (Dehning and Stratopoulos, 2002).

This can be expressed in the following formula:

$$\begin{aligned}\text{Return on Assets} &= \text{Net Profit Margin x Total Assets Turnover}\\ &= (\text{Net Income / Sales}) \text{ x } (\text{Sales / Total Assets}) \qquad (1)\end{aligned}$$

3. LINKING SUPPLY CHAIN OPERATIONS' PERFORMANCE TO THE COMPANY'S FINANCIAL STRATEGY

Although supply chain performance and the organization's financial performance have been widely studied; few empirical studies of their relationship have been presented (Toyli et al., 2008).

According to Lambert et al. (2005), a supply chain management framework can be evaluated by how it is linked to the corporate strategy (the strategic driver) and the extent to which it helps the achievement of strategic objectives. Therefore, it is important that the firm's supply chain management framework should be aligned to the firm's financial strategy to achieve the strategic objectives. The scope of the SCOR model framework is not linked directly to corporate strategy. SCOR processes are developed based on the operations strategy while the functional strategies and the corporate strategy are not explicitly considered in this model.

To overcome the above obstacle, according to the proposed methodology, supply chain performance metrics will be linked to the company's financial strategy through determining the priorities of the supply chain performance measurement attributes with respect to the priorities of the financial performance drivers.

Presutti Jr. and Mawhinney (2007) developed SCORcard performance metrics to measure the performance of both processes and the outputs of these processes of an organization. According to these SCORcard performance metrics, supply chain performance and company's financial performance are linked through measuring the performance of the processes in terms of reliability, responsiveness, flexibility, cost, and asset management based on SCOR model metrics and measuring the performance of the outputs of these processes in terms of revenue, cost, and assets based on the Economic Value Added (EVA) concept. Figure 1 illustrates the supply chain financial link as demonstrated in the SCORcard performance metrics:

Performance attributes					
Customer-Facing			Internal-Facing		
Reliability	Responsiveness	Flexibility	Cost	Assets	
					Revenue
					Cost
					Assets

(Adapted from: Supply Chain Council, cited by Presutti Jr. and Mawhinney, 2007)
Figure 1: SCORcard Performance Metrics

The method proposed in this study focuses on the performance of both processes and the outputs of processes to link supply chain processes performance to the priorities of the company's financial strategy. According to the proposed method, supply chain performance metrics measure the performance of processes in terms of reliability, responsiveness, agility, cost, and asset management based on SCOR model standard performance metrics, while financial performance metrics measure the performance of the outputs of these processes in terms of efficiency and profitability based on Du Pont ratio analysis to identify the focus areas for improving a company's financial performance.

Using the FAHP technique, the relative importance weights of supply chain processes performance measures are determined with respect to the priorities of the company's financial strategy, and consequently, new supply chain strategy is set based on these priorities. Supply chain index (SCI) is calculated after applying the new supply chain strategy to evaluate to what extent supply chain operations' performance is linked to the company's overall financial strategy.

Finally, Du Pont ratio is measured again after applying the new supply chain operations' strategy to test the impact of supply chain operations' performance on enhancing the company's overall performance.

4. FRAMEWORK FOR THE PROPOSED METHODOLOGY

The procedures for the proposed method are illustrated in this section then in the next section a case study will be conducted to demonstrate the applicability of the proposed method:

Step one: the Du Pont ratio for the company is calculated and then compared to the industrial average to reveal the company's overall financial performance relative to the industrial average and highlight financial performance drivers (revenue, cost, and total assets) that need improvement.

Step two: the relative importance weights of the main supply chain performance measures are determined with respect to the priorities of financial performance drivers using the FAHP technique. The main factors to enhance financial performance are improving profitability and efficiency through increasing revenue, managing cost and increasing asset utilization, based on Presutti Jr. and Mawhinney SCORcard performance metrics ;SCOR model supply chain performance metrics -which includes five performance categories: reliability, responsiveness, agility, cost, and asset metrics-can drive financial performance.

Step three: the company now is in a position to set its new supply chain strategy based on the priorities of the financial performance and with respect to the relative importance weights of the main supply chain performance measures. Since the financial performance evaluation reflects the contribution of each of the financial performance drivers and highlights drivers that need improvement, setting the new supply chain strategy with respect to the priorities of these drivers can contribute to enhancing the overall financial performance. According to SCOR model standard performance metrics, each supply chain performance measurement attribute at each level corresponds to certain processes in the supply chain. Based on the relative importance weights of the main supply chain performance measures, the company can identify the related processes that need improvement and their corresponding performance indicators in order to align with supply chain strategy, and consequently, with the company's overall strategy.

Step four: to evaluate the efficiency and the effectiveness of the new supply chain strategy, a proposed SCI is calculated for the company to reflect to what extent supply chain operations' performance is linked to the company's overall financial strategy. To calculate SCI, the performance rate assigned for each of the five main supply chain performance measures based on SCOR model index is adjusted by the relative importance weights of these measures. By multiplying the relative importance weight of each measure (W) by its performance rate (R), the weighted rate (WR) of each performance measure is determined. The weighted rates of all performance measures are then aggregated to determine the company's SCI.

The traditional method for evaluating supply chain operations' performance is unable to track such improvement as it ignores the relative weight of each measure. The following numerical example illustrates that traditional SCI, which assumes that supply chain operations' performance measures are equally weighted, is unable to reflect the actual performance. To trace the actual change in supply chain operations' performance the relative importance weight of each measure should be taken into consideration.

Measure	Beginning of the accounting period			Ending of the accounting period			Change direction
Supply chain operations' performance							
	R	W	WR	R	W	WR	
Reliability	1	12%	0.12	0.6	12%	0.072	Unfavourable
Responsiveness	0.6	18%	0.108	0.8	18%	0.144	Favourable
Agility	0.6	30%	0.18	0.8	30%	0.24	Favourable
Cost	0.6	35%	0.21	0.8	35%	0.28	Favourable
Assets	0.8	5%	0.04	0.6	5%	0.03	Unfavourable
Aggregated performance	3.6/5 =**0.72**		**0.66**	3.6/5 =**0.72**		**0.76**	
Traditional SCI	0.72			0.72			No change (doesn't reflect the actual performance)
Weighted SCI	0.66			0.77			Favourable

Table 1: SC operations' performance before and after applying the new SC strategy

Step five: Du Pont ratio is calculated again at the end of the year to test the impact of the new developed supply chain strategy on enhancing the company's overall financial performance. Figure 2 illustrates the research method:

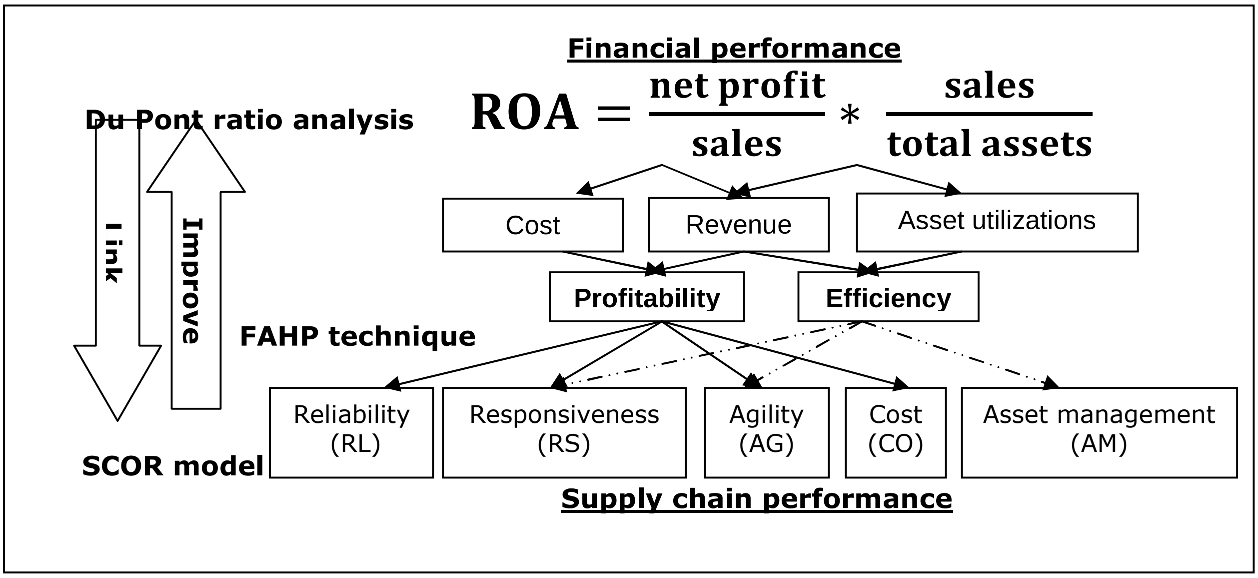


Figure 2: Linking supply chain operations' performance to financial performance

5. CASE STUDY

To demonstrate the applicability of the proposed method, a case study on an Egyptian natural bottled water company has been considered. The measurement algorithm was carried out by means of the Microsoft Excel Spreadsheet. The brief illustrative procedures for applying the proposed method are divided into the following five steps.

Step one: the Du Pont ratio of the Company was calculated and compared to the industrial average to evaluate the company's financial performance in terms of profitability and operating efficiency. The analysis revealed that the company has the ability to generate sales from assets employed in business compared to the industry average. However, the company's financial performance in terms of profitability is far below the industry average, which highlights that the company has a problem in generating profit from its sales. Based on the result of the Du Pont ratio analysis, the focus area for enhancing the financial performance should be to improve its profitability, especially through managing its costs.

Step two: Since the priorities of the financial performance drivers were determined, the supply chain operations' performance can be linked to the company's overall financial strategy. To create this link, FAHP approach was used to determine the relative importance weights of the main supply chain performance measures (RL, RS, AG, CO, AM) with respect to the priorities of financial performance drivers.

A group of four decision makers was assembled comprising the business planning manager, the commercial manager, the quality assurance manager, and Engineering division manager and asked to rank the importance weight of the main supply chain performance measures –with regard to each financial performance driver priority using pair-wise questionnaire. The relative importance of two elements was rated using a scale with the values 1, 3, 5, 7, and 9, where 1 denotes equally important, 3 for slightly more important, 5 for strongly more important, 7 for demonstrably more important, and 9 for absolutely more important.

To aggregate the experts' responses, a fuzzy prioritization method - derived from Chang et al. (2009) - was adopted. Based on this fuzzy prioritization method, the expert's comparison judgments were represented as fuzzy triangular numbers where the uncertainty and imprecision of evaluations can be tackled. A fuzzy pair-wise comparison matrix based on triangular fuzzy numbers (L, M, U) was used in expressing the consolidated opinions of the experts. Where L denotes the minimum numerical value, U denotes the maximum numerical value and M is the geometric mean which represents the consensus of most experts.

As the preferences of experts were relatively subjective opinions, their responses could differ depending on the degree of environmental uncertainty and depending on whether the experts adopt a conservative or optimistic attitude when determining their preferences. Therefore, the degree of experts' confidence in their preference should be taken into consideration. To determine that, α was used to express the environmental uncertainty; in addition, λ was used to express the degree of experts' confidence in their preference. For the questionnaire responses, $\alpha = 0.5$ was used to express that environmental uncertainty is steady; and $\lambda = 0.5$ was used to express that a future attitude is fair.

To establish the aggregate pair-wise comparison matrix, the defuzzication of the triangular fuzzy numbers derived from the fuzzy pair-wise comparison matrix was done. And consequently the aggregate pair-wise comparison matrix was established. Then, the Eigenvector method was used for weight calculation.

To verify the consistency of the comparison matrix, consistency ratio (C.R.) was calculated for the aggregate pair-wise comparison matrix. The consistency ratio (CR) is defined as a ratio between the consistency of a given evaluation matrix (consistency index CI) and the consistency of a random matrix (RI). The RI is the random index representing the consistency of a randomly generated pair-wise comparison matrix. The CR of a decision should not exceed 0.1. In the case CR exceeds 0.1; the comparison matrix is considered inconsistent and should be improved (Meixner, 2009).

Finally, the relative importance weights of the main supply chain performance measures were determined.

Step three: Once the relative importance weight of each main supply chain performance measure had been determined, the company could identify supply chain processes that need improvement and their corresponding performance indicators based on SCOR model standard performance metrics.

As the company needs to improve its profitability particularly through managing its costs, the most suitable supply chain strategy to align with this goal is to focus on enhancing the processes to which cost and agility performance measures correspond. According to the Company's strategic priorities, the main aims of its supply chain strategy should be managing supply chain costs and increasing supply chain agility.

Step four: at the end of the accounting period, SCI will be calculated before and after applying the new SC strategy to evaluate the efficiency and the effectiveness of the SC operations' performance in linking to the company's overall financial strategy.

Based on the SCOR model, supply chain operations' performance can be evaluated by assigning performance rate (0.2, 0.4, 0.6, 0.8, or 1) for each of the supply chain performance measurement attributes throughout the hierarchy of the supply chain, from the process element levels till the configuration level, to assess the performance of the company's supply chain operations with respect to the SCOR model standard performance metrics. Then, the performance rates of all measurement attributes will be aggregated- using averaging aggregation method- throughout the hierarchy of the supply chain to determine the performance rate of the main supply chain performance measurement attributes at the top level (RL, RS, AG, CO, AM). Where [0.2] denotes very poor performance, [0.4] denotes poor performance, [0.6] denotes good performance, [0.8] denotes very good performance, and [1] denotes excellent performance with respect to the performance rating scale. The performance rates of the five main supply chain performance measures will then be adjusted by their relative importance weights. By multiplying the relative importance weight of each attribute (W) by its performance rate (R), the weighted rate (WR) of each performance measurement attribute will be determined. The weighted rates of the performance measurement attributes at the top level are then aggregated to determine the company's SCI. Comparing the index before and after applying the new SC strategy will reflect the improvement in supply chain operations' performance with respect to SC strategic priorities.

Step five: By the end of the accounting period, Du Pont ratio for the company will be calculated again and analyzed to determine the impact of improving supply chain operations' performance on enhancing the company's overall financial performance. Comparing Du Pont results at the end of the accounting period to the beginning of the accounting period will show the change in the profit margin% which reflects the impact of the supply chain operations' performance on enhancing the company's overall performance.

6. CONCLUSION

This research illustrated a method to link supply chain operations' performance to the company's overall financial strategy. According to this method, the priorities of the main supply chain performance measurement attributes were determined with respect to the priorities of the financial performance drivers.

Applying this method, enables companies to set the supply chain strategy based on the priorities of the financial performance drivers. Since the financial performance evaluation reflects the contribution of each of the financial performance drivers and highlights driver that need improvement, setting supply chain strategy with respect to the priorities of these drivers can contribute to enhancing the overall financial performance.

REFERENCES

- Abdul Moneim, A.F. (2008) 'Fuzzy Genetic Prioritization in Multi-Criteria Decision Problems' *Jordan Journal of Mechanical and Industrial Engineering*, Vol. 2, No.4, pp. 175–182.
- Anderson, D.L., Britt, F. and Favre, D. (1997) 'The seven principles of supply chain management', *Supply Chain Management Review*, Vol. 1, pp.31-43.
- Chan, F.T.S. and Qi, H.J. (2003) 'An innovative performance measurement method for supply chain management', *Supply Chain Management: An International Journal*, Vol. 8, No.3, pp.209 – 223.
- Chan, F. T.S. Chan, H.K., and Qi, H.J. (2006) 'A review of performance measurement systems for supply chain management' *International Journal of Business Performance Management*, Vol. 8, No.2-3, PP. 110-131.
- Chang, C.W., Wu, C.R. and Lin, H.L. (2009) 'Applying fuzzy hierarchy multiple attributes to construct an expert decision making process', Expert Systems With Applications, Vol. 36, No.4, pp. 7363-7368.
- Chopra, Sunil & Meindl, Peter (2007), *Supply Chain Management: strategy, planning &operation.*3rd ed. New Jersey: Pearson Prentice-Hall.
- Dehning, B. and Stratopoulos, T. (2002) 'DuPont analysis of an IT-enabled competitive advantage' *International Journal of Accounting Information*, Vol.3, No.3, PP. 165-176 .
- Deng, H. (1999) 'Multicriteria analysis with fuzzy pair-wise comparison' *International Journal of Approximate Reasoning*, Vol. 21, No.3, pp. 215–231.
- Harison, A. and Van, H.R. (2005), Logistic*s Management and Strategy.* 2nd ed. New Jersey: prentice-Hall.

- Huan, S.H., Sheoran, S.K and Wang, G. (2004) 'A review and analysis of supply chain operations reference (SCOR) model' *Supply Chain Management*, Vol.9, No.1, PP. 23-29.
- Huang, S.H., Sheoran, S.K. and Wang, G. (2004) 'A review and analysis of supply chain operations reference (SCOR) model' *Supply Chain Management*, Vol.9, No.1, PP. 23-29.
- Huang, S.H., Sheoran, S.K. and Keskar, H. (2005) 'Computer-assisted supply chain configuration based on supply chain operations reference (SCOR) model' *Computers & Industrial Engineering*, Vol.48, No.2, PP. 377–394.
- Hwang, Y.D., Lin, Y.C. and Jr, J.L. (2008) 'The performance evaluation of SCOR sourcing process—The case study of Taiwan's TFT-LCD industry' *InternationalJournal of Production Economics*, Vol.115, No.2, PP. 411– 423.
- Kahraman, C., Cebeci, U. and Ulukan, Z. (2003) 'Multi-criteria supplier selection using Fuzzy AHP' *Logistics Information Management*, Vol. 16, No. 6, pp. 382-394.
- Kunadhamraks, P. and Hanaoka, S.(2008) 'Evaluating the logistics performance of intermodal transportation in Thailand' *Asia Pacific Journal of Marketing and Logistics*, Vol. 20, No. 3, pp. 323-342.
- Kuo, M.S., Liang G. S. and Huang, W.C. (2006) 'Extensions of the multicriteria analysis with pair-wise comparison under a fuzzy environment' *International Journal of Approximate Reasoning*, Vol.43, No.3, pp. 268-285.
- Lambert, D.M., Dastugue, S.J.G., and Croxton, k.L. (2005) 'An evaluation of process-oriented supply chain management frameworks' *Journal of Business Logistics*, Vol. 26, No. 1, pp. 25-51.
- Leung, L.C. and Cao, D. (2000) ' On consistency and ranking of alternatives in Fuzzy AHP ' *European Journal of Operational Research*, Vol. 124, No.1, pp. 102-113.
- Lockamy, A. and McCormack ,K. (2004) 'Linking SCOR planning practices to supply chain performance' *International Journal of Operations & Production Management*, Vol.24, No.12, PP. 1192-1218.
- Meixner, O. (2009): Fuzzy AHP Group Decision Analysis and its Application for the Evaluation of Energy Sources. *In: University of Pittsburgh, Pittsburgh, Pennsylvania, USA. The 10th International Symposium on the Analytic Hierarchy/Network Process, Multi-criteria Decision Making, July 29 - August 1 2009.* [on line] Available at:< http://www.isahp.org/2009Proceedings/index.htm> [Accessed 10th April 2010].
- Mikhailov, L. (2003) 'Deriving priorities from fuzzy pair-wise comparison judgments' *Fuzzy Sets and Systems*, Vol. 134, No.3, pp. 365–385.
- Mikhailov, L. (2004) 'A fuzzy approach to deriving priorities from interval pair-wise comparison judgments' *European Journal of Operational Research*, Vol. 159, No.3, pp. 687–704.Presutti Jr, W.D. and Mawhinney, J.R. (2007) 'The supply chain _finance link', *Supply Chain Management Review*, Vol. 11, No.6, pp. 32–38.
- Theeranuphattana, Adisak and Tang, John C.S. (2008) 'A conceptual model of performance measurement for supply chains' *Journal of Manufacturing Technology Management*, Vol.19, No.1, PP. 125-148.
- Toyli, J., Häkkinen, L., Ojala, L. and Naula ,T. (2008) 'Logistics and financial performance, An analysis of 424 Finnish small and medium-sized enterprises' *International Journal of Physical Distribution & Logistics Management*, Vol.38, No.1, PP. 57-80.

EXPLORING HOW TO SUSTAIN BUSINESS PROCESS IMPROVEMENT GAINS IN COMPLEX OPERATIONS

Barry Evans[a] *and Robert Mason*[b]
[a] Lean Enterprise Research Centre & [b] Logistics and Operations Management Section, Cardiff Business School, Aberconway Building, Colum Drive, Cardiff, CF10 3EU, UK

INTRODUCTION

"Value is the measure of desire for a product and its related services" (Bowersox et al., 2000) and its successful provision needs to be an on-going endeavour if a business is to be able to sustain itself. Providing value for consumers is, therefore, the life-blood of the organisation. However, businesses are constantly faced with seemingly conflicting objectives in their efforts to provide superior value for consumers. These include, for instance, the yearning to consistently improve service levels, balanced against the needs to constantly reduce production/procurement costs, or cut storage and distribution expenditure. In essence, the ultimate strategic challenge many organisations encounter is to marry up, over the short, medium and long terms, the requirements to be effective, yet also efficient, simultaneously.

To address this dilemma management leaders in many organisations have noted the folly and limitations of taking a functional optimisation approach, typified by the era of mass production, and have moved to a business process improvement philosophy. There are many incarnations of this broad idea such as business process improvement (BPI) itself, coined by James Harrington (Harrington, 1991), business process re-engineering (BPR) promoted by Michael Hammer (Hammer, 1990), supply chain management, first discussed by Oliver and Weber (1982) and lean management (Womack et al, 1990). However, numerous authors (for example, Zokaei and Hines, 2007, Walters 2006) have highlighted in recent years that there has been an over-concentration of focus on efficiency improvements derived from these business process concepts and a dearth of a presence of a broader strategy of deploying business process thinking and initiatives to deliver enhanced and sustainable effectiveness for consumers. This is an important observation, as Bowersox et al. (2000) note that demand and supply side changes have meant that the understanding and perception of value has broadened beyond just low prices, and as such, organisations need to be sophisticated at ensuring value provision is effective and relevant, as well as efficient.

This paper reflects on this and examines whether, at the current time characterised by a challenging economic scenario following the financial crash of 2007/2008, there is still a discernible tendency to prioritise business process efficiency improvements over enhanced effectiveness in practice in industry. The study takes a leading economic sector in a major developed country, the manufacturing industry in the United Kingdom, as a case study setting for the research. The flavour of the moment in the United Kingdom, in many companies and most public sector organisations, appears to be to manage for more austere times ahead. This would, on the face of it, suggest that cost savings, derived from business process ideas are an imperative. However, as we have noted above, there would appear to be profound dangers in pursuing this course too myopically, and conceiving the need for cost reductions as a simple cause and effect issue – i.e. to make operations more efficient through the blunt reduction of operations expenditure.

The paper focuses on a major survey of UK manufacturing companies, who are pursuing lean thinking as a business process improvement strategy. The objective of the study is to evaluate whether the UK manufacturing industry is predominantly pursuing an improved efficiency agenda, or a more enlightened and broader enhanced effectiveness strategy in the current commercial environment that they are encountering. It is hoped that the results will have important implications for practice as well as academics who are interested in how business process improvement initiatives are managed.

LITERATURE REVIEW

A Business Process Perspective

Today, it is commonly conceived that business, through a series of processes, provides products and services to the end-consumer, who act as arbiters, the Kings or Queens of the value chain. They determine the winners and losers through their decisions to buy or not. Typically, this perspective can be modelled as a systems approach with inputs into a process, or a series of processes, and outputs from these processes to provide a purpose – value for end-consumers. The idea behind business process management is that any business process, irrespective of its scope, can be continuously managed and improved through a control and feedback mechanism to ensure it is fit for purpose (Figure 1).

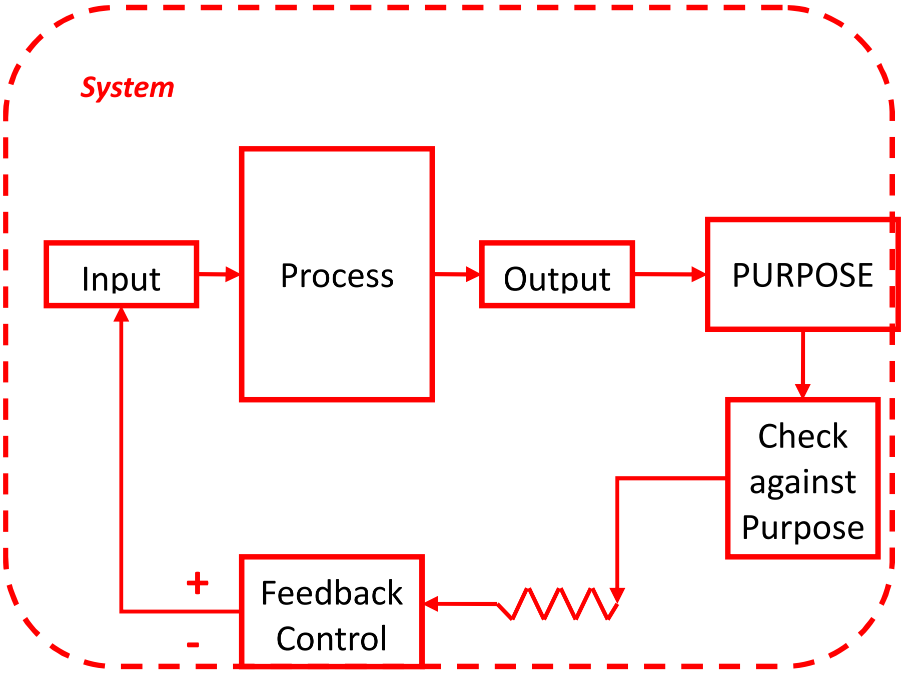


Figure 1: Conceiving of the supply chain process as a basic system, which is constantly refined to ensure it is *"fit for purpose"*

Too Myopic a Focus on Efficiency Improvement!

One of the key objectives of any business is to manage the elements of the system within its span of control with the purpose of providing enhanced value to the end-consumer. Bowersox et al. (2000) defines the end-customer as "the last point in a supply chain where a product or service bundle is purchased for consumption" and as such they note that "the end-customer could be a consumer or an intermediate channel member who purchases a product or component as an industrial input".

Value has many elements. For example, Bowersox et al. (2000) propose that end-customers have three value perspectives: low price – provided through efficiencies (*efficiency value*); *market value* achieved through product service positioning, i.e. assortment and convenience; and *relevancy value*, providing value where, when and how the end-customer wants it – accommodating the business/lifestyle of the consumer. They conclude that "the provision of these combined values can be considered as the purpose of the firm".

Traditionally, price, delivered through efficiency value measures, has been an important element in competitiveness. Indeed, this is still the case today in many markets. However, assuming that value is determined solely by efficiency savings would be to substantially mis-understand the nuances involved.

Nevertheless, business process concepts such as SCM have become to be dominated and characterised by efficiency strategies, such as bullwhip, or six sigma, which largely aim to dampen variability to reduce uncertainties (see Holweg et al., 2005). A comprehensive study of definitions for lean management (Hu, 2011) found that although there was very little consensus, most referred to lean as a means of managing/removing wastes through better flow control – i.e. an efficiency weapon. In summary, these tools and techniques observable in SCM, lean management BPI or BPR, although credible, are predominantly about enhanced process capability derived through reducing cost by tightening controls and standards and managing uncertainties. Indeed, Christopher and Holweg (2011) characterised the efficient supply chain as one with a "a control focus to reduce variability and thus cost to compete", with a "short term decision time horizon".

"Invariably they (supply chains) have been designed with efficiency in mind".
(Christopher and Holweg, 2011)

Other authors, such as Walters (2006) and Zokaei and Hines (2007), concur with these views. Zokaei and Hines (2007), after an extensive literature review, argued that there was, in the supply chain management domain, "an over-emphasis with supply chain efficiency improvements and an underplaying of the innovative supply chain facts which could enhance consumer value". Walters (2006) noted his concern that "supply chain efficiency is mistaken for effectiveness, with un-due short-term emphasis on cost-reduction at the expense of contribution to broader goals".

Conceiving Value Enhancement from a Broader Perspective
The principal reasons for conceiving of value as a wider concept than efficiency delivery can be evidenced from the demand and supply side of business. On the demand side authors are increasingly emphasising the need for organisations to sense and react to customers' full values and expectations from products and services. Consequently, they have encouraged the view that the customer should be placed at the heart of process systems improvement. For example, Meyer and Schwager (2007), worry passionately about the "customer's experience" and suggest that managing the customer should not be left to those who have functional responsibility for customer facing tasks, but should extend also through to all process and functional leaders. They define customer experience as the "internal and subjective response customers have to any direct or indirect contact with a company" and argue that each customer's needs and value net is different and contingent upon the situation they face. They are also dynamic and thus it is vital organisations can sense and have the capabilities to rapidly react to changes. Thus the voice of the customer needs to be placed centrally in the organisation and form the root of all decision making. Price reduction resulting from efficiency value improvement in business processes is only one potential element of the armoury available to improve values. Thus authors such as Walters (2006) argue that "the old downstream supply chain model is too limiting and that the customer needs to be brought into the equation". He cites Holmstrom et al (2000), who argue that demand chain management, which they define as "the complex web of business processes and activities that help firms understand, manage and ultimately create consumer demand", is fundamentally different to supply chain management, "which emphasise efficiencies in the production and logistics processes".

On the supply side some authors too challenge those who narrowly conceive business process improvement ideas such as SCM or lean thinking as just a set of ideas or tools to remove inefficiencies and suggest that instead they should be seen as business philosophies, which can provide enhanced effectiveness through continuous improvement of purpose (e.g. Zokaei and Hines 2007). Thus a system is developed to achieve both value and waste elimination yes, but as a secondary by-product of continuous improvement, which should be the primary goal. This echo's Spear and Bowen's (1999) finding in the Decoding the DNA of the Toyota Production System that suggested that observers wishing to understand and potentially imitate the success of Toyota needed to "go beyond the tools and practices …..and look at the system itself".

RESEARCH QUESTION

Stemming from this debate flows the following question which guides the research. In the current relatively uncertain and challenging economic climate, in particular following the financial crash of 2007/08, are manufacturing organisations pursuing an efficiency dominated change agenda, or are they taking a broader view and making effectiveness improvement their primary concern?

METHOD

A large survey of UK manufacturing organisations practicing lean was conducted in the summer (June) of 2010 by a leading trade journal in the UK, the *Manufacturer*. Members of the magazine's reader panel were contacted with a total 212 responses being received. The survey looked, in particular, at the extent that *"Lean Thinking"* was being used by organisations and probed into a range of issues connected with its implementation, such as the factors that drove lean initiatives, the level of success attained from them and the quantification of benefits. It then looked at perceived success rates over a range of time, dependent on how long the organisation had been implementing lean. The authors were asked to assess and analyse the data directly from the survey, the highlights of which are reported in this paper.

FINDINGS

The first question asked what business objectives were their key motivators for business in the implementation of lean? Table 1 summarises the response. Efficiency improvements dominate the most popular results notably *"seeking cost reductions"* (89%). *"Improving supply chain efficiency"* (57%) also was a significant finding, all be it not so pronounced. Business effectiveness objectives, such as *"improving quality"* (61%) and *"improving customer service"* (59%), were not identified by all companies as core objectives. It is this balance of 40% who did not regard *"quality improvement"* or "*customer service"* development as a key concern, as they implemented lean, which is the most revealing finding from the question posed. A further indicator of proof of a lack of understanding of the primacy of effectiveness is the response that only 38% saw *"professional development of staff"* as key.

WHICH OF THE FOLLOWING WERE THE KEY MOTIVATORS FOR YOUR BUSINESS IN THE IMPLEMENTATION OF LEAN (Mark as many as apply)	**% Indicating this Applied**	**Highlighted Remaining Balances (i.e. it was not KEY)**	**Category Of Motivator**
Cost reduction	89%		Outcome
Optimising materials flow around the factory	68%		Driver
Improving quality	61%	**(39%)**	Driver
Improving customer service	59%	**(41%)**	Driver
Improving supply chain efficiency	57%		Outcome
Professional development of staff	38%	**(62%)**	Driver
Reducing time to market	34%	**(66%)**	Driver
Improving maintenance	25%	**(75%)**	Driver
New product development	18%		Strategy
Justifying investment in new equipment (other than ICT)	11%		Capital Planning
Investment in new IT systems	8%		Capital Planning
Optimising existing IT systems	7%	**(93%)**	Driver
New customer acquisition	5%		Strategy
Other	5%		
Investment in new comms/telecomms system	0%		Capital Planning

Table 1: Motivators for Business in the Implementation of Lean

The second question asked, what areas of the organisation have lean initiatives been implemented? The results, summarised in Table 2, have been classified into either "point" improvements, where a function of the company has been targeted or "end-end" improvements, where a positive answer would suggest a more systemic approach has been adopted. What appears to be prevalent is a piece-meal approach rather than the pursuit of a more holistic strategy to lean implementation. This again supports evidence of the pursuit of lean as a vehicle for cost removal from a segment of a process rather than a wider embracing of lean for enlargement of the effectiveness capability of the organisation and its supply chain enterprise. Relatively few companies appear to be engaged in "end to end" improvement, yet this is where the source of sustainable improvement is most likely to be found.

IN WHAT AREAS OF YOUR ORGANISATION HAVE YOU IMPLEMENTED LEAN INITIATIVES (Mark as many as apply)	**Area**	**"Point" Improvement**	**"End to End" Improvement**
Shop floor	93%	point	
Maintenance and operations	60%	point	
Purchasing	42%	point	
Distribution	38%	point	
Suppliers	37%		E-2-E
Upstream supply chain - suppliers	24%		E-2-E
Finance	22%	point	
Sales and marketing	18%	point	
IT/communications	15%	point	
Downstream supply chain - distributors	15%		E-2-E
Other	6%		

Table 2: Areas of the organisation where lean initiatives have been implemented

Question three (Table 3) probed into the degree of improvement from lean manufacturing. The top ranking results are predominantly dominated by efficiency biased outcomes ("*reduction in costs", "increased efficiency", "reduced waste" and "reduced inventory"*). The lower ranked results are more effectiveness focussed *("complete on time delivery"* - ranked 6th, *"increased customer satisfaction"* – ranked 7th *and "increased product quality"* – ranked 8th!)

Rank by "Major Imp."	**FOR EACH OF THESE POTENTIAL BENEFITS OF LEAN MANUFACTURING, HOW MUCH IMPROVEMENT HAS THERE BEEN?**	Major Improvement	Minor Improvement	No Improvement
1	Reduction in costs	52%	44%	4%
2	Increased efficiency	47%	48%	5%
3	Reduced waste	47%	44%	9%
4	Increased profitability	42%	46%	13%
5	Reduced inventory	39%	41%	21%
6	Complete and on-time delivery	35%	54%	10%
7	Increased customer satisfaction	32%	52%	16%
8	Increased product quality	26%	61%	13%
9	Reduced time to market	16%	49%	35%
10	Employee retention	8%	45%	47%

Table 3: Areas / Degree of improvement stemming from lean initiatives

The final question asked about the degree of success (*poor, moderate, successful or very successful*) experienced since the implementation of lean. The results have been categorised in terms of length of time since the commencement of the lean initiative (Table 4). What stands out is the scores for companies in the 5-10 years category (30% of the total sample), with over half of those (53%) stating they were only moderately successful, only 40% feeling successful or very successful results have flowed from the initiative. The question which flows from this finding, in terms of future research, is why are such a low proportion of companies, who have been implementing lean for 5-10 years, experiencing successful or very successful outcomes from it? At this stage only a hypothesis can be proposed, that by under-focussing on building improved effectiveness capability and concentrating on efficiency measures instead, companies have compromised heir potential for sustained performance success. This is clearly only speculation and would need to be more fully researched, but the findings from academic research on the common understanding of lean and the results from the earlier questions suggest that this is a distinct possibility.

		Degree of Success			
TIME SINCE THE COMMENCEMENT OF THE LEAN INITIATIVE	**% of responding companies per category**	**Poor**	**Moderate**	**Successful**	**Very Successful**
less than 12 months	**11%**	0%	45%	45%	10%
1 - 2 years	**21%**	10%	14%	52%	24%
2 - 5 years	**28%**	7%	25%	54%	14%
5 - 10 years	**30%**	7%	**53%**	20%	20%
over 10 years	**10%**	10%	20%	50%	20%
Totals	**100%**	6%	33%	43%	18%

Table 4: The degree of success experienced following the introduction of lean

ANALYSIS

The Lean Management Journal ran advertising for their Lean Directors' event in September 2010 on "Leading Transformation in Complex Environments". The headline stated: *"with only 5 - 10% of lean business transformation actually achieving sustainable success, those who take on the mantle of leading change programmes must be either, hugely confident, naively optimistic or simply crazy".* The question that follows is that - despite organisations devoting time, effort and resource to changing their organisation – why do 90 - 95% fail? They appear to achieve marginal, transient benefits at best – often there is no improvement, or things actually worsen.

This survey shows how organisations in UK manufacturing pursuing lean agendas are approaching change. It provides evidence of the high incidence of moderate and un-sustained improvement, re-affirming the conventional thinking that leads to 90 - 95% failing to achieve sustainable success. The findings suggest that nearly all the organisations responding are primarily focused on internal efficiency improvement hoping to achieve cost reduction: cost reduction and efficiency improvement consistently emerge as the priorities. Internally-focused boundaries are the norm. Effectiveness goals are not uniformly rated as high priorities. Depressingly, this survey re-affirms the prevalence of conventional thinking that leads to failure to achieve sustainable success. The academic literature suggested that organisations should be very wary of increasing value through efficiency initiatives. So what would a blueprint for renewed pursuit of effective delivery and sustainable improvement look like?

Blueprint for Sustainable Improvement

Toyota and Tesco are two lean exemplars, who have achieved sustained improvement over many years. The solution they adopt is simple, yet not easy to adopt. It starts with an obsessive focus on their customers: they are both primarily driven by understanding and providing customer value. This is to say they are totally focused on their priority being given to effectiveness first, in the knowledge that efficiency will follow. To support this, the full range of ideas within what has been termed as the "House of Lean" is adopted and capabilities developed. The key is this is done completely rather than through any tendency to "pick and choose". Thus, the argument is to focus not just on tools, not just on JIT and Flow, but both pillars of the "House of Lean" – JIT and Jidoka. So as was stated above, the solution is "simple" – not the same as "easy"!

Essentially, what Toyota, Tesco and other lean exemplars understand about achieving sustainable improvement is that that a business, with its wider supply chain (suppliers, customers and connecting mechanisms) is a complex system. Improvement to that system has to be "systemic": i.e. it has to address the whole rather than tinkering with parts in isolation. Tinkering aimed at efficiency improvement runs exactly the same dangers as Deming's "tampering". Thus it risks worsened efficiency, unintended consequences and transient improvement at best. However, "systemic" improvement focuses on the system's purpose and how to achieve effective change of system purpose delivery. This ensures improvement will be sustained and unintended consequences avoided. The "House of Lean" has two pillars – JIT and Jidoka – improvement must address both. Figure 7 provides a schematic of the constituents of this strategy for sustainable improvement.

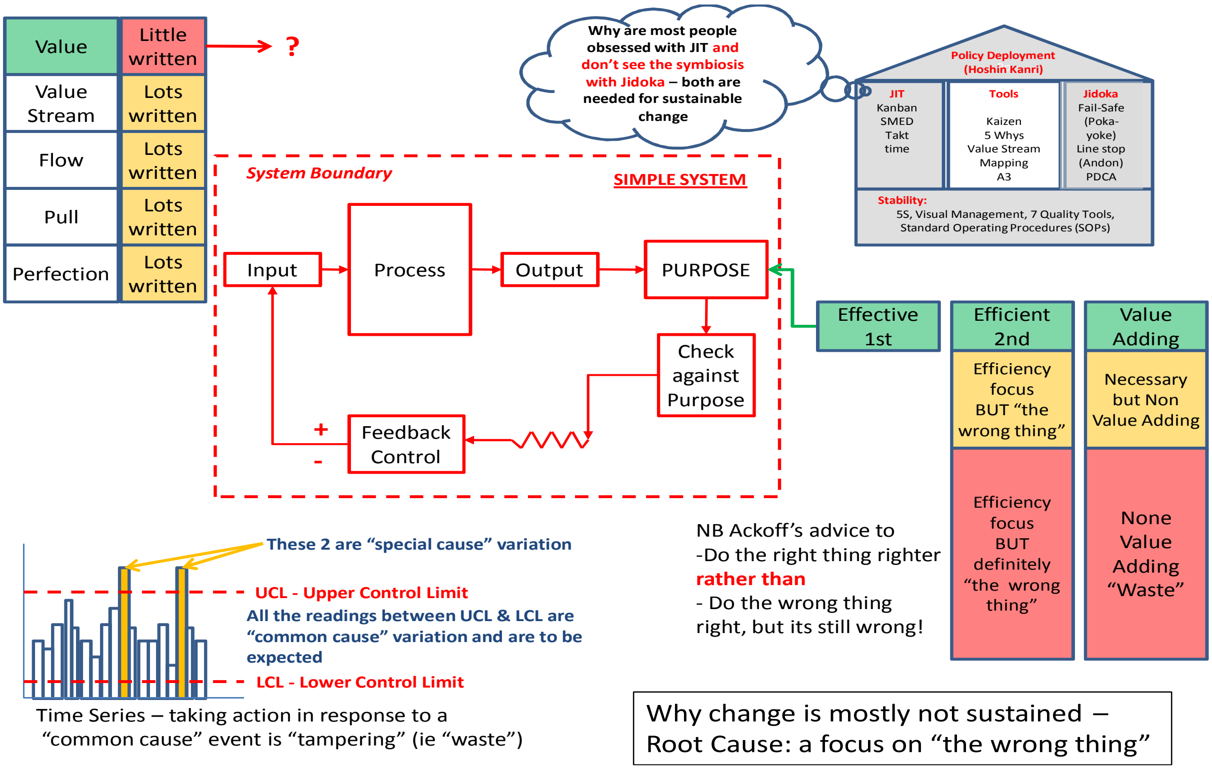


Figure 2: Focus on system purpose to deliver sustained improvement

This shows that the starting point is focused on "Value" and "Value Adding" steps, which are the ingredients of delivering system purpose – i.e. effectiveness. However, efficiency improvement is a relative measure aimed at making an "output"/"input" ratio larger. If the particular ratio being targeted is based on either non-value adding activity (waste), or necessary but non-value adding activity (future waste) then the risks of transient improvement and unintended consequences are obvious. Starting by addressing "system purpose" avoids this.

It is also a compelling counter to the "quick win" approach to improvement seemingly evidenced in the survey results. This approach tends to look for early cost reductions based on efficiency improvement. The "quick wins" are secured, business priorities change, but the essential longer-term root cause improvements don't happen and the early gains disappear! A counter approach would be to expect to invest in advance of sustained improvement (for example, in raising workforce capability, providing better leaders and general skills training – both generic and technical). This is clearly the antithesis of the "quick win" approach.

CONCLUSIONS

The paper has reflected upon on the efficiency versus effectiveness debate, which some authors have suggested "will characterise the conduct of commerce in the third millennium" (Hunt and Duhan, 2002). There is a recurring irony that organisations may continue to do the same as they have always done – focus on cost reduction and efficiency improvement – yet expect that this time they will achieve a different outcome. This would seem to support Einstein's definition of lunacy: "doing the same thing that we've we done hundreds of times before, yet expecting a different outcome!"

The survey, disappointingly suggests that currently there is a strong temptation for leaders in UK manufacturing to primarily follow this efficiency route again. The research analysis encourages organisations to try a different way; the true lean approach. By developing organisational "effectiveness" (enhanced quality, improved customer service, professional staff development and "Gemba-based" improvement) then, through a process of continuous improvement, efficiency improvement can still be delivered, but as part of the outcome of sustainable success. The principal feature capabilities and adopted behaviour should focus upon improving quality, enhancing customer service, professional development of staff and "Gemba-based" improvement. Critically, the approach avoids unintended consequences AND can be continued again and again in the spirit of continuous improvement (the world of "one-off" improvement initiatives is not adopted – improvement is everyone's job).

Cost reduction and efficiency improvement does not appear in this counter-intuitive approach – but the benefits of cost reduction and efficiency improvement are delivered as part of the outcome of sustainable success. In summary, the paper advocates that managers should take Einstein's advice and start doing things differently – focus on effectiveness – system purpose and "value". Efficiency will follow!

REFERENCES

Bowersox, D. J., Closs, D. J. and Stank, T. P. (2000) Ten Meg-Trends that will Revolutionise Supply Chain Logistics Journal of Business Logistics, Vol. 21, No.2, pp.1-16

Christopher, M. and Holweg, M. (2011) "Supply Chain 2.0": Managing Supply Chains in the Era of Turbulence Int. Journal of Physical Distribution and Logistics Management Vol. 41, No. 1, pp. 63-82

Collis, D. J. and Rukstad, M. G. (2008) Can You Say What Your Strategy Is? Harvard Business Review, April 2008 pp. 83-90

Hammer, M. (1990) Reengineering work: don't automate, obliterate. Harvard Business Review Vol. 68, No. 4, pp. 104-12

Harrington, H. J. (1991) Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity and Competitiveness, McGraw Hill, New York, NY.

Holweg, M. Disney, S., Holstrom, J. and Smaros, J. (2005) Supply Chain Collaboration: Making Sense of the Strategy Continuum. European Management Journal, Vol. 23, No. 2, pp. 170-181

Hu, Q. Williams, S., Mason, R. and Found, P. (2011) Lean Implementation within SMEs: A Literature Review 18th EUROMA Conference 3-6 July, Cambridge, UK

Hunt, S. D. and Duhan, D. F. (2002) Competition in the Third Millennium: Efficiency or Effectiveness? Journal of Business Research, Vol. 55, Issue 2, pp. 97-102

Meyer, C. and Schwager, A. (2007) Understanding Customer Experience. Harvard Business Review, February 2007, pp. 117-126

Spear, S. and Bowen, H. K. (1999) Decoding the DNA of the Toyota Production System Harvard Business Review, September – October 1999 pp. 96- 106

The Manufacturer – "Manufacturer Survey - June 2010" To be published in an imminent "Manufacturer" electronic report

Zokaei, K. and Hines, P. (2007) Achieving Consumer Focus in Supply Chains. International Journal of Physical Distribution & Logistics Management Vol. 37, No. 3, pp. 223-247

Oliver, R. K. and Webber, M. D. (1982) Supply Chain Management: Logistics catches up with Strategy in M. Christopher (ed.) Logistics: The Strategic Issues. London: Chapman and Hall 63-75

Walters, D. (2006) Demand Chain Effectiveness – Supply Chain Efficiencies Journal of Enterprise Information Management Vol. 19, No. 3, pp.246-261

Womack, J., Jones, D. T. and Roos, D. (1990) The Machine that Changed the World, Rawson Associates, New York, NY

MOBILE INTELLIGENCE FOR REPORTING OF SUPPLY CHAIN KPI'S

Helen Rogers, Kulwant Pawar
Nottingham University Business School, University of Nottingham, Jubilee Campus, UK
helen.rogers@nottingham.ac.uk, *kul.pawar@nottingham.ac.uk*

Nicoleta Tipi
University of Huddersfield, Queensgate, Huddersfield, UK
Huddersfield University
n.tipi@hud.ac.uk

Research Paper
Topic area – Supply Chain Performance Assessment

ABSTRACT
A Supply Chain Manager is in the departure lounge at Munich airport waiting for her flight to London to discuss size curves of the latest range of sports shoes with the Retail Manager of the company's flagship London retail store. The SC Manager opens up an application on her smartphone that displays the stock levels for the season's top selling shoes. She immediately sees that the stock turnover for this range is much higher at the London store than at other leading stores across Europe. The London Retail Manager wants to change the range profile to better reflect UK customer sizes and tastes. The SCM Manager has a printed version of last year's size curves (showing how many of each size were shipped and sold to the UK), however, she would like to see what the latest figures are for this quarter. She simply opens the size curve application on her smartphone and calls up the figures she needs.

This kind of scenario is increasingly being played out by executives and managers (many of whom spend very little time in the office) as they travel to meetings remote from their colleagues and the company intranet. It is fair to say that in many cases, retrieval of the information that is required is not as easy as the above situation implies. There are many reasons for this including restrictions on data sharing/retrieval, scattering of data across formats/ databases and insufficient specification by the managers of their requirements.

Mobile intelligence systems utilise devices such as mobile phones and tablet computers (smartphones, iPad, Playbook, etc.) as handheld workstations for users to access and analyse real time information. Essentially they allow managers to access performance information quickly and in an easy to communicate visual way (e.g. bar charts, pie charts etc. see for example Figure 1). Mobile intelligence in a supply chain management reporting context allows users to access supply chain-related information anywhere and make quick, informed decisions. Supply chain specific examples include delivery performance tracking and alerts for low inventory levels. Mobile phone applications ('Apps') can now offer managers more opportunities to connect and share information than, for example, a laptop due to the level of connectivity and network coverage around the world.

Figure 1. Source: Mexon Technology (2011)

There are however some restrictions to mobile reporting. For many businesses, it is neither feasible nor advisable that all performance measurement reports are made available as instant downloads on mobile devices, owing to the volume of data involved and the potential security issues. It is currently unclear as to which SC-related key performance indicators (KPIs) are most suited to mobile business reporting and what features managers are looking for (e.g. viewing charts and reports, monitoring movements in KPIs, alerts, drill down reports, etc.). This research seeks to address this issue.

At this early stage in the research, we present our research approach and reflections from a preliminary interview with a supply chain manager. We conclude with the presentation of a research agenda for further work in this area.

INTRODUCTION AND LITERATURE OVERVIEW

Making analytical tools and performance data accessible on smartphones allows companies to interact with their customers and business partners in real time, thereby improving services and boosting productivity (Fitzgerald, 2010). Although there is a lot of business interest in this area, a preliminary literature review revealed limitations and gaps regarding research into the use of mobile intelligence systems for reporting of supply chain KPIs. This is perhaps not surprising, because although measuring business performance (Kaplan and Norton, 2001; Neely, 2005) and more specifically supply chain performance is a well established field (Bhagwat and Sharma, 2007; Van Weele, 2009), using mobile devices to do this is rather new (Eckerson, 2011; Laskowski, 2011).

In 2009 Cegedin Dentrite released its Customer Relationship Management (CRM) suite; ‘Mobile Intelligence’ for BlackBerry smartphones (Vecchione, 2009). In this instance the Mobile Intelligence enabled delivery of accurate route planning, customer profiles, daily organisers, and pre- and post-call functionality with the potential to improve productivity and reduce administrative tasks. As reported by the CEO these new mobile applications enable the commercial team to carry only one device to communicate with their key stakeholders, organise their schedule and access key information stored in their Mobile Intelligence CRM system.

Practical impediments however still exist. According to industry analysts and vendors, the mobile applications market is being held back by small screen sizes and limitations in storage, memory and computing power (Brodkin, 2008). In the same article Brodkin mentioned that if a transaction is put on a mobile phone it must have some sense of time-criticality, as most users do not want their smartphone to simply act as a second computer. Airinei and Homocianu (2010) point out that many limitations of the mobile Business Intelligence applications are related to the physical features of the mobile devices and also to the architecture of the mobile operating systems (MOS) they are running on, together with a lack of compatibility with the corresponding operating systems on personal computers. Poor editing facilities were also mentioned. They conclude that all of these issues overcomplicate the idea of having a reliable mobile system useful to remotely connect in order to input data, find-out critical information, take real-time decisions and communicate them effectively.

Additional practical and strategic limitations to mobile BI are highlighted by Ericson (2011) with security, being a major area of concern to users. This is especially true when personal devices are misplaced or lost, as commercially-sensitive information can be involved. Business challenges also arise from the fact that many companies use a 'patchwork' of performance measures, rather than a consistent and integrated performance measurement system. This makes selecting and extracting the business performance reports in a unified and comparable manner for executives to use on their mobile devices, an extremely difficult and often impossible task.

Performance measurement systems are usually used to collect information and provide managers with relevant data to improve their decision making process. They are also known to evaluate, monitor and control operations. There are many benefits reported when performance measurement systems are used, however there are also issues linked to using dedicated measurement systems. The number of measures within organisations is large and in many cases on the increase. It is also the case that within many performance measurement systems obsolete and inconsistent measures exist (Tipi, 2009). This situation arises because when new technological changes are considered within organisations, new performance measures are added or developed to reflect these changes and simply added to current measures (Driva et al., 2000). However, if by adding new measure the whole system in not re-evaluated and the old, obsolete measures are not removed, problems occur that adversely affect the whole performance measurement system whereby the information provided may no longer be accurate.

Measures are also considered in organisations at different levels of aggregation from operational, tactical to strategic level. Using aggregated measures to evaluate and control supply chain systems could create difficulties in identifying the source of the problem for which a change decision is required (Tipi, 2009). It is also the argument where managers have to operate with a very large number of measures, some which could be obsolete or inconsistent. However if any of the obsolete measures are part of an existing aggregated measure, the process of removing measures from a system requires considerable attention from a process modelling point of view.

Therefore challenges such as these related to the use of corporate performance measurement systems need to be addressed, before they can be considered for transference to mobile devices.

There are many possibilities in terms of research directions when one considers the use of mobile intelligence systems as a business tool. This includes data capture (real time operational factors such as RFID, fault reporting, customer feedback and other performance data) and data reporting/retrieval. One could also investigate how new applications could be developed for these devices to make them an integral part of a company's SCM activities. In order for product and system development projects such as these to be successful, a thorough organisational readiness assessment needs to be carried out.

We have chosen to focus on reporting and retrieval and more specifically on the issue of how existing SCM data can be presented in an executive-friendly way (i.e. aggregated, pictorial-based data) on mobile devices. Clearly owing to the screen size there are restrictions in terms of the amount of information that can be displayed at any one time.

OBJECTIVES

Given that the broad aim of this study is to explore how mobile devices can be used to assist with reporting of supply chain-related performance measures, we specifically seek to identify SC managers' preferred form of measurement output while they are on the move (i.e. away from their 'desk') and link this to what can be realistically achieved on mobile devices.

This last aim needs to take into account the physical restrictions presented by the small screen size and limitations to the amount of live data that can be accessed in real time. This research can show how SCM information can be displayed and used on a mobile phone, and it can also demonstrate how businesses should aggregate-disaggregate information and make it available to be used in different formats.

As the term 'supply chain performance measures' can be interpreted in many ways and potentially produce a wide range of KPIs, we will restrict our scope to operational performance measures.

Michael Saucier, President of Transpara (Saucier, 2010) considers that Mobile Business Intelligence should focus on operational data rather than future planning data. If strategic decisions are required, which employ complex data evaluation, managers will need the time, space and computer capabilities to allow for these analyses. He therefore considers that these type of scenarios will not be suitable for mobile phone reporting. He also points out that mobile phones should focus on "here and now" metrics. Developing this theme further, the ideal mobile BI solution should include a combination of multiple data sources to generate a real-time solution, therefore implying that it should not just be a front end version of traditional BI applications.

RESEARCH DESIGN AND METHODOLOGY

The first steps in this project will be to carry out a thorough literature review – taking in not only traditional journal contributions but also technical blogs, online journals and outputs from communities of practice. This use of non-conventional literature sources is required, owing to the newness of the field.

Secondly we will carry out a needs analysis of a sample of supply chain managers to establish the kinds of information they need 'on the move' and in what form (heat maps, bar charts, pie charts, dashboards, etc.).

From a preliminary interview using a set of pilot questions with a 3rd Party Logistics manager in Egypt[1], it was identified that the Balanced Business Scorecard concept was used (Kaplan and Norton, 2001). Four main areas were identified as performance measures; customer satisfaction, operational excellence, human capital and financial performance. Individual measures are considered for each of these categories and they are assessed through a quarterly survey against pre-set KPIs. However a performance measurement system is in place in this case, and as the manager indicated the use of mobile devices in assessing performance measures will not be a workable solution upon applying the concept of Balanced Scorecard as this is currently implemented in their company.

[1] conducted by A.T. El-Said, a Masters student at the University of Huddersfield, UK

The next stage will involve talking to business reporting software vendors to discuss the technical limitations, possibilities and future developments. This in turn could lead to the development of a SCM reporting-related application for mobile devices.

INITIAL CONCLUSIONS AND NEXT STEPS

We believe that this will be one of the first studies of this nature. As such, the research output has the potential to make a positive contribution to both academia and to practitioners.

In line with our initial findings and reflections on the areas of mobile intelligence for reporting of supply chain KPIs, we propose the following research agenda:

1. Ongoing literature review of developments in mobile BI reporting
2. Design, development and launch of a large scale questionnaire (sample size 1000, target response rate >100) to address supply chain specific BI reporting requirements of managers. Responses will be sought from managers across the world, taking in a variety of industries.
3. Gain additional insights from supply chain managers to determine their firms' readiness assessment for mobile BI for SCM. Responses will be sought from online business forums and business networking sites.
4. Gain insights from business reporting software vendors to provide a view on the technical possibilities and limitations of BI reporting using mobile devices.
5. Design and development of an SCM-specific BI reporting application for mobile devices.

REFERENCES

Airinei, D. & Homocianu, D., 2010. The mobile business intelligence challenge. *Economy Informatics,* 10 (1)**,** 5-12.

Bhagwat, R., Sharma, M.K., 2007. Performance measurement of supply chain management: A balanced scorecard approach, Computers & Industrial Engineering, 53, 43-62.

Brodkin, J., 2008. Mobile app coming along - slowly. *Network World,* 25 (18)**,** 26.

Driva H; Pawar KS & Menon U (2000) - Measuring Product Development Performance in Manufacturing Organisations, International Journal of Production Economics, 63 (2000), pp147-159

Eckerson, W., 2011. Business Intelligence Market Evolution, http://www.b-eye-network.com/blogs/eckerson/archives/2011/03/bi_market_evolu.php, (accessed 3 March 2011).

Ericson, J., 2011. Putting Business Intelligence Mobility to Work BI Portal, http://www.biportal.org/BI_news?mode=PostView&bmi=54212, (accessed 14/04/2011).

Fitzgerald, M., 2010. BI goes mobile: Delivering business intelligence apps to employee smartphones can boost customer service. *Computerworld,* 44 (15)**,** 24.

Kaplan, R.S., Norton, D.P., 2001. Transforming the Balanced Scorecard from Performance Measurement to Strategic Management: Part I, American Accounting Association; Accounting Horizons, 15, 1, 87-104.

Laskowski, N., 2011. New Survey Reveals Mobile BI is on the Upswing, http://searchbusinessanalytics.techtarget.com/news/2240034180/New-survey-reveals-mobile-business-intelligence-is-on-the-upswing, (accessed 1/4/2011).

Marshall, D. McIver, R., Lamming, R., 2007. Influences and outcomes of outsourcing: insights from the telecommunications industry, Journal of Purchasing and Supply Management, 13, 4, 245-260.

Mexon Technology, 2011. http://www.mexontechnology.com/images/iPhone/iPhone_dashboard.png, (accessed 4/04/2011).

Neely, A., 2005. The evolution of performance measurement research. International Journal of Operations & Production Management, 25(12), 1264-1277.

Performance Management Association Portal, 2010. Mobile BI Market Study http://www.performanceportal.org/entry/some-background-our-impendingstudy , (accessed 12/03/2011).

Saucier, M., 2010. 5 mobile BI myths. DashBoard Insight: Turning data into knowledge, available at: http://www.dashboardinsight.com/articles/new-concepts-in-business-intelligence/5-mobile-bi-myths.aspx, (accessed 14/04/2011).

Tipi, N.S., 2009. Modelling performance measures for supply chain systems using discrete event simulation, Proceedings of the 14th International Symposium on Logistics, Istanbul, Turkey 5-8 July, 2009, p34.

Van Weele, A., 2009. Purchasing and Supply Chain Management, Cengage Publishing, Chapter 14.

Vecchione, A., 2009. Cegedim launches mobile intelligence CRM application. Medical Marketing & Media, 44 (11), 16.

SC PERFORMANCE – A DRIVER OF COMPANY PERFORMANCE

Prof. Dr. Gernot Kaiser[2]*, Dr. Inga-Lena Darkow, Heiko Wöhner*
EBS Business School
SC Management Institute, Wiesbaden, Germany
gernot.kaiser@ebs.edu

The fundamental goals of good logistical operations are punctuality, accuracy, and quality, as stated in the international symposium on logistics (ISL) aims. And in terms of ongoing globalisation and value chain decompositions those performance indicators are applied to SC management. However as the Handbook of Metrics for Research in OM by Aleda Roth et al. (2008) shows, metrics on SC (SC) performance are being redeveloped over and over again and different dimensions of SC performance use subsets of the same items.

THEORETICAL BACKGROUND

Already in 1990 Ferdows and De Meyer proposed the so named *Sand Cone Model* for manufacturing capabilities. Thereby quality, dependability, speed, and cost efficiency are built upon another, instead of being substitutes. Figuratively spoken it is like building up bigger sand cones by pouring on more and more sand. If the capabilities are built in this sequence "quality–dependability–speed–cost efficiency" they become formidable competitive weapons regarding the long-term success of the firm (Ferdows & De Meyer, 1990).A multi-dimensional construct (metric) was developed by Bowersox et al. (1999) to measure SC performance. Nevertheless cross-validation of the applied measures in the Bowersox study is rare and relates to only some parts of the performance metric. Therefore, our purpose is to examine the contribution of SC performance on company performance by an empirically investigation.

METHODOLOGY OF RESEARCH WORK

Drawing from an extensive literature review, expert interviews, and in line with the Sand Cone Model, we decomposed SC performance in accuracy, flexibility, alignment, and cost. Accordingly, company performance is decomposed in adaptability, market performance, and economical performance (see Figure 1 for the structure).

We consolidated the different metrics of Fugate et al. (2010), Gunasekaran et al. (2004), and Sengupta et al. (2006) to derive valid and reliable measures for our questionnaire. The resulting survey instrument was pre-tested for face validity. The target sample was drawn from a contact database comprised of logistics and SC experts. The database is managed by the German Logistics Association. According to the sampling procedure, 307 target respondents were individually contacted and sent the questionnaire if they agreed to participate. 124 respondents returned the questionnaires. We compared early and late responses (Armstrong and Overton, 1977). There is no statistical difference on a 95%-confidence level between the early and late responses and the deviations of branches $\chi2(7) = .297$, $p = .444$; the number of employees ($U = 1{,}390.5$; $p = .061$); and for the number of SCM employees ($U = 1{,}204.5$; $p = .680$). Partial least squares structural equation modeling technique was applied to analyze the data (Chin, 1998). T-values were computed applying a bootstrapping procedure with 500 randomized samples (sampling with replacement) from the origin sample and of origin cardinality (n = 124). All measures are checked for validity and reliability and found to fulfil all required thresholds.

ANALYSIS AND RESULTS

We utilized SmartPLS 2.0 M3 (Ringle et al., 2005) to conduct the different magnitudes of impact for all performance dimensions. The results are shown in Figure 1.

[2] To correspond to.

DISCUSSION
SC Accuracy shows a significantly strong positive impact of .576 (t = 8.150) on SC Flexibility, a significantly medium positive impact of .484 (t = 6.081) on SC Alignment, and also a significantly medium positive impact of .308 (t = 3.164) on SC Cost. Taking the first impact as an example, for one more point on the measurement scale utilized for SC Accuracy slightly more than half a point remains on the measurement scale utilized for SC Flexibility. Bearing in mind the huge amount of other possible drivers of SC flexibility, this is meant to be a strong impact.

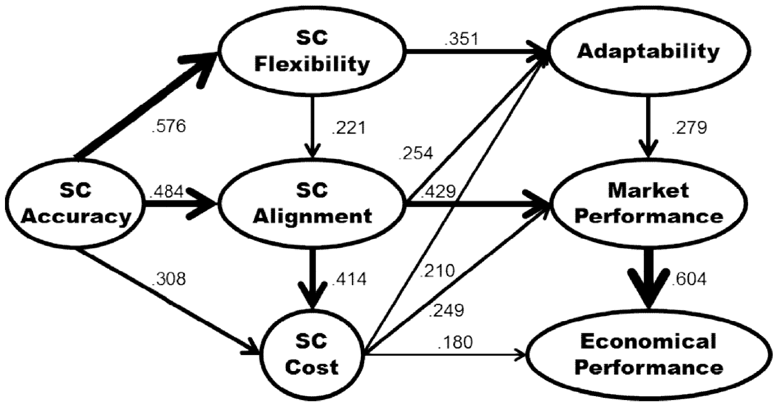


Figure 1: The impact of SC performance on company performance

Note: Width of arrows correspond to magnitude of impact

The finding is in line with the Sand Cone Model. To deliver the right goods, in right quantity, in adherence to agreed time windows is the basis for all further SC performance's dimensions. Thereby nearly a third (R^2 = .331) of SC Flexibility's statistical variance in the sample can be explained by SC Accuracy. This is an additional plus factor for SC Accuracy. However our analysis shows no significant direct impact of SC Accuracy on the company performance's dimensions (no arrow in Figure 1). It seems that SC Accuracy's impact "hides" behind the other dimensions of the SC performance.

SC Flexibility itself shows a small but still significantly positive impact of .221 (t = 2.344) on SC Alignment and a significantly medium positive impact of .351 (t = 3.583) on Adaptability. Also this finding is in line with the Sand Cone Model. The ability to handle unstandardized orders and to cope fast with customer order changes and changing delivery dates, impacts positively the alignment of a SC and the adaptability of the whole company regarding demand fluctuations, changes in customer needs, and technological changes. Thereby more than a third (R^2 = .406) of SC Alignment's statistical variance in the sample can be explained by SC Flexibility and SC Accuracy. However, our analysis shows no significant direct impact of SC Flexibility on Market Performance or Economical Performance. It seems that flexibility in a SC drives the adaptability of the focal company, but is not recognised and appreciated by the customers.

SC Alignment shows a significantly strong positive impact of .414 (t = 4.811) on SC Cost, a significantly medium positive impact of .254 (t = 2.396) on Adaptability, and a significantly strong positive impact of .429 (t = 5.495) on Market Performance. The advantage of successfully developed relationships along the SC creates customer value and thereby satisfies customers, attracts new customers, and increases demand. However, our analysis shows no significant direct impact of SC Alignment on Economical Performance. It seems that an aligned SC creates a sustainable competitive advantage in terms of market adaptation but does not pay off directly in cash.

SC Cost show a small but still significantly positive impact of .210 (t = 2.283) on Adaptability, a significantly medium positive impact of .249 (t = 4.018) on Market

Performance, and also a small but still significantly positive impact of .180 (t = 2.219) on Economical Performance. Thereby nearly a half (R^2 = .442) of SC Cost's statistical variance in the sample can be explained. It is remarkable that SC Cost show a positive impact on all company performance's dimensions. That means SC Cost is the only SC performance's dimension that directly influences the economic performance of a company. It seems that an efficient SC reduces financial resources that were invested to cope with changing customers' needs, were utilized for price reductions to gain market shares, but also were simply retained to increase margins, the return on demand, investment, and assets.

Adaptability shows a significantly medium positive impact of .279 (t = 4.149) on Market Performance. Thereby nearly a half (R^2 = .443) of Adaptability's statistical variance in the sample can be explained. It is remarkable that between, e.g., the ability to cope with changes in customers' needs and satisfied or new customers there is only a medium interconnection. It seems that Adaptability is the (small) basis for market success in a fast changing environment – it is necessary but not sufficient. Combined with SC Alignment and SC Cost, Adaptability explains nearly two third (R^2 = .655) of Market Performance's statistical variance in the sample. This is tremendous bearing in mind that no dimensions like product or service quality or sales activities are measured in our model.

Market Performance shows a significantly strong positive impact of .604 (t = 7.848) on Economical Performance. Thereby more than a half (R^2 = .537) of Economical Performance's statistical variance in the sample can be explained by SC Cost and Market Performance. It is not astonishing that market success, that creates the cash flow for a company, heavily influences the bottom line effect. This gives strong evidence for the nomological validity of our utilized company performance model. As often noted in the last paragraphs there are both, direct and indirect influences of each dimension. Of ultimate interest is thereby the sum of all direct and indirect impacts (so named *total effect*) of SC performance's dimensions on the Economical Performance. SC Accuracy has no direct impact on company performance's dimensions. However in connection with the strong and medium impacts on SC Flexibility and SC Alignment and SC Cost resp., SC Accuracy has a significantly medium positive total effect of .424 (t = 7.702) on Economical Performance (see Figure 2). Nearly the same total effect shows SC Alignment (.453, t = 7.512). It seems that on the one hand accuracy in the SC is indeed the basis of all SC performance and therefore a strong driver of a company's economic performance. On the other hand an aligned SC has a huge impact on company's market success and therefore takes a more "direct route" to the bottom line effect.

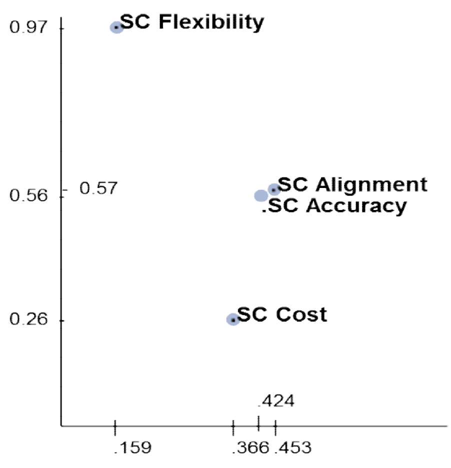


Figure 2: Total effect vs. dimension's maturity

Note: Abscissa indicates the sum of all direct and indirect impacts of a SC performance's dimension on the Economical Performance; ordinate indicates dimension's maturity

SC Cost show a significantly medium positive total effect of .366 (t = 4.689) on Economical Performance. Although an efficient SC has a direct impact on company's economic performance, it has only a medium impact on market performance and is therefore outpaced by accurate and aligned SCs. SC Accuracy and SC Alignment over-compensate the direct impact of SC Cost on Economical Performance. And last but not least SC Flexibility shows a small but still significantly positive total effect of .159 (t = 3.482) on Economical Performance. This weak impact is due to the only small impact on SC Alignment and the missing impact on Market and Economical Performance. This small total effect of a flexible SC is even more surprising in relation to the maturity of SC Flexibility. We calculated the mean construct score of SC Flexibility for our sample as a proxy for maturity. On average all companies rate their SC flexibility over all items to be somewhat better (score: 1.0) than the best competitor. In contrast SC Cost bear only an overall construct score of 0.26. Concerning cost, a huge proportion rates their company to be not that good as the best competitor (score: -1.0). Figure 2 shows a clear inconsistency between total effect and maturity for SC Flexibility and SC Cost.

CONCLUSIONS

Your results indicate that SC performance has a huge impact on company performance. More concrete: Nearly two third of statistical variance in companies' market success can be explained by SC performance and more than 50 per cent of the companies' economic performance. Accuracy in a SC has no direct impact on company performance's dimensions. Therefore we conclude that accuracy is merely a qualifier but not an order winner. Of cause accuracy has a huge indirect effect due to its very basic characteristics for the "higher" SC performance's dimensions. Also flexibility is not visible to the customers but is the basis for a company's adaptability success. In contrast alignment is indeed visible to the customers and drives especially market performance. Last but not least SC costs are driven directly and indirectly by all other SC performance's dimensions. At the same time those costs are drivers for all company performance's dimensions. Costs are the only direct driver for a company's economic performance.

In sum there is strong evidence for the Sand Cone Model. Thereby SC performance's dimensions are neither "pure" complements nor "pure" substitutes. On the one hand on a short term basis and driven by greed achieving better cost in a SC create direct bottom line impact. But the total effect of an aligned and accurate SC is somewhat stronger than that of an only efficient SC. On the other hand and in case some fast reactions on technological changes are needed it is better to allocate resources more in flexibility related activities and achieve direct impact on company's adaptability than to enhance accuracy and wait until learning effects will spill over to flexibility. There are two clear points for SC managers: First, resources should be reallocated from flexibility to more effective SC performance's dimensions. In relation to its total effect SC Flexibility is too mature. A flexible SC drives mainly company's adaptability. But this adaptability is only weakly connected with company's market success. Investments in alignment, accuracy or both pay off more. Second, SC cost related activities should be developed more. In relation to its total effect SC Cost is not enough mature. It could be often seen in practice, that companies start to develop their SC accuracy and then step further towards a flexible, aligned, and efficient SC. We can only recommend going ahead on this path. The data was drawn from German companies and thus, the results might only be transferable to other regions to a certain extent. Especially the maturity of SC performance's dimensions may differ, e.g. between well developed and emerging economies. Although your empirical results are valid and reliable additional cross validation would be needed to overcome the noted regional focus. Moreover, it would be of high interest to utilize the same sample for a follow up questionnaire to shift the SC impact focus to a more evolutionary approach.

REFERENCES

Armstrong JS, Overton, TS (1977) Estimating nonresponse bias in mail surveys, Journal of Marketing Research 14, 396–402.

Bowersox DJ, Closs DJ, Stank TP (1999) 21st Century Logistics: Making SC integration a reality, Oak Brook: Council of Logistics Management.

Chin WW (1998) The partial least squares approach to structural equation modelling, in Marcoulides GA, Modern Methods for Business Research, Mahwah: Lawrence Erlbaum.

Ferdows K, De Meyer A (1990) Lasting Improvements in Manufacturing Performance, Journal of Operations Management 9, 168–184.

Fugate BS, Mentzer JT, Stank TP (2010) Logistics performance: efficiency, effectiveness, and differentiation. Journal of Business Logistics 31, 43–62.

Gunasekaran A, Patel C, McGaughey RE (2004) A framework for SC performance measurement, International Journal of Production Economics 87, 333–347.

Ringle CM, Wende S, Will A (2005) SmartPLS, Hamburg: University Press.

Roth AV, Schroeder RG, Huang X, Kristal MM (2010) Handbook of Metrics for Research in Operations Management, Thousand Oaks: Sage.

Sengupta K, Heiser DR, Cook LS (2006) Manufacturing and Service SC Performance: A Comparative Analysis, Journal of Supply Chain Management 42, 4, 4–15.

LOGISTICS TRIAD COLLABORATION AS AN ENABLER OF UNCERTAINTY REDUCTION: A FMCG LONGITUDINAL STUDY

Vasco Sanchez Rodrigues[1], Andrew Potter[2], Robert Mason[2], Abrie de Swardt[3], Anneri Robinson[3]
[1] University of Plymouth Shipping and Logistics Unit
[2] Cardiff University, Cardiff Business School, Logistics and Operations Management Section
[3] IMPERIAL Logistics Southern Africa

ABSTRACT
Business relationships in logistics should be assessed and managed on a tripartite rather than a dyadic basis between all three inter-connected parties (Bask, 2001, Stefansson, 2006). One barrier inhibiting the reduction of transport uncertainty in logistics triads is insufficient collaboration (Sanchez-Rodrigues et al., 2009, 2010a). The aim of this paper is to investigate how a logistics provider can reduce transport uncertainty by collaborating with its customer. A longitudinal case study has been undertaken in a South African grocery retail logistics network. Data was collected between January 2009 and January 2010. According to the data collected, as a result of a number of collaborative improvement initiatives implemented jointly between the two companies, the costs and CO_2 emissions generated due to uncertainty was reduced by 88% and the average vehicle utilisation in the network was increased by 40%.

INTRODUCTION
Recently, there have been considerable efforts focused on undertaking research in logistics collaboration. The delivery process within supply chains has become a more integral part of the manufacturer's product offering, and thus logistics activities within supply chains need to be designed, run and planned by taking a partnering orientation (Whipple and Gentry, 2000). The principal cause for focus in logistics research is the dyadic relationship between the shipper and the logistics service provider (Bask, 2001), since logistics contracts were usually managed between either the shipper and the logistics service provider or the customer and the logistics service provider, but not by all of them. The logistics service provider forms a link between two entities in the supply chain, the shipper and the customer (Mentzer et al., 2001). Several researchers have suggested that relationships in logistics should be assessed and managed on a tripartite rather than a dyadic basis between all three inter-connected parties (Larson 1992, Bask, 2001, Larson and Gammelgaard, 2001, Stefansson, 2006, Naim et al., 2010).

Nowadays, within the grocery sector, the entity setting the delivery rules is primarily the retailer and the relationship between retailers and logistics service providers has become a critical success factor. As markets matured the power began to shift to the buyers who, "demand higher quality goods that more closely matched their desires" (Pine, 1993). There has been plenty of conceptual works in logistics research which emphasise the importance of a collaborative logistics triad. However, there has been little empirical research focused on linking supply chain collaboration and uncertainty mitigation. The aim of this paper is to investigate how a logistics service provider can reduce transport uncertainty by collaborating with its customer through the application of a longitudinal case study.

In the following section of the paper, a review of the literature on transport uncertainty and logistics collaboration is presented. Subsequently, a discussion on the key research work is undertaken to develop a frame of reference for the analysis of the data collection. Furthermore, the key methodological issues and data collection and analysis methods applied in the research are outlined. Also, the findings from the longitudinal study are presented. Finally, the paper concludes with a summary of the main findings, managerial implications, limitations and further research of the study.

TRANSPORT UNCERTAINTY AND SUPPLY CHAIN COLLABORATION

Several researchers have developed models to study the effects of uncertainty on supply chain performance. Davis (1993) identified three main sources of uncertainty affecting the performance of manufacturing operations: the supply side, the demand side and the manufacturing process. Mason-Jones and Towill (1998) extended Davis' (1993) supply chain uncertainty model by adding a fourth source of uncertainty, namely control systems. Van der Vorst and Beulens (2002) identified three dimensions to measure supply chain uncertainty: quantity, quality and time.

All these works have been focused on identifying and measuring sources and causes of uncertainty affecting manufacturing operations. A number of researchers have identified collaboration-related issues as one of the main root causes of uncertainty affecting supply chain performance. A lack of supply chain integration and control was identified as a significant uncertainty source affecting manufacturing (Geary et al. 2002, Childerhouse and Towill 2003) and logistics performance (Cavinato, 2004). A lack of communication in the ordering process (Geary et al., 2002) and inconsistent demand forecasting undertaken by different supply chain members (Mason-Jones and Towill, 1998) have also been identified as significant factors affecting the coordination and synchronisation between different supply chain processes. Furthermore, a lack of coordination and integration between marketing and other supply chain functions, e.g. manufacturing and logistics, has been identified as the main cause of demand uncertainty (Vickery et al. 1999, Sanchez-Rodrigues et al 2010a).

In addition, McKinnon et al (2009), Bichescu & Fry (2009) and Sanchez-Rodrigues et al (2010a) also found that inaccurate volume forecasts from customers due to insufficient collaboration between the customer and the logistics service provider as one of the main causes of transport uncertainty. Moreover, Geary et al. (2002), Naim et al. (2006) and Sanchez-Rodrigues et al. (2010a) have identified lack of integration in all the strategic areas with supply chains as one of the main issues that affects logistics operations. Sanchez-Rodrigues et al. (2009, 2010b) undertook comparative case studies in two UK FMCG road freight transport operations run by a logistics service provider and a retailer respectively. They found that the main barrier inhibiting the reduction of transport uncertainty in the processes of transport planning and delivery execution was a lack of collaboration between road freight transport operations and their customer. As Naim et al. (2006) emphasise, if the demand for transport is not managed in a holistic and collaborative way, road freight transport operations are more vulnerable to be affected by uncertainty.

RESEARCH APPROACH

The research follows an inductive-to-deductive approach; since even though a longitudinal study was undertaken in an inductive manner, as Miles and Huberman (1994) commented, 'induction and deduction are dialectical rather than mutually exclusive'. The longitudinal study applied has aspects of two main methodological paths applied in inductive research: case study and action research. Action research was applied since the performance of the logistics triad was measured before and after the improvement initiatives were implemented. However, the researcher was not present in the logistics triad operation studied to observe the implementation of the improvements.

As recommended by Maylor and Blackmon (2005), a non-probabilistic purposive sampling strategy was applied to select the case study to find an exemplar logistics triad in terms of collaboration. The unit of analysis of this case study is the secondary distribution network of a South African grocery retailer. The logistics triad studied, formed by distribution centres (the shippers), a dedicated logistics service provider (the carrier) and customer's outlets (the customer), was selected for undertaking the longitudinal study. There are a number of reasons why this particular logistics triad was chosen:

- This logistics triad is considered an exemplar case in South Africa in terms of logistics collaboration and efficiency improvement (de Swardt et al, 2011).
- The relationship between the logistics service provider and the customer is in a mature state.
- The members of the triad were kept to further improve their operations, and saw uncertainty reduction as an important aspect of this.

In the planning stage, the research framework was presented to a panel of practitioners who plan and execute the delivery process within the central planning office of the secondary distribution operation studied. In this meeting, the research framework was refined. Also, it was agreed that one of the authors would follow the execution of the transport plan for a one week period. The data collection was undertaken in two Phases. Phase 1 collected data for the week commencing on 4th January 2009 while Phase 2 reflected changes after 12 months, taking data from the week commencing 5th January 2010. According to the management staff at the logistics service provider, these two weeks can be described as typical weeks which can reflect what happens throughout the year.

Data was collected on the nature of unexpected events and their impact on the total number of miles travelled and the additional time spent in the delivery process. In order to measure the impacts of these unexpected events two measures were used, 'extra distance' and 'extra time'. These two measures have been developed and tested by Sanchez-Rodrigues et al. (2009). Data was gathered from archival reports at the logistics service provider. Also, the distance impact of traffic congestion was measured in Phase 2 only, due to the fact that the logistics service provider acquired an appropriate Telematics system after Phase 1 was concluded. Moreover, in the two data collection phases, the transport planning process was assessed by re-planning the network to estimate the cost and CO_2 effects of consolidating outlet deliveries which had less than half-full shipments and were located at close proximity.

In addition, a calculation of the cost and CO_2 emissions of all the causes of 'extra distance' and 'extra time' recorded in Phases 1 and 2 were undertaken by using the cost per kilometres, the labour cost per hour and the average fuel consumption given by the operations manager in charge of the logistics service provider studied, and the carbon conversion factor recommended by Defra (2009), 2.63 Kg of CO_2 per litre of fuel. The findings are shown in the form of percentages and proportion of products moved per kilometre rather than in absolute numbers due to confidentiality restrictions as well.

Between March and May 2009, changes in processes at the customer (volume demand forecasting and picking and sorting of products at distribution centres) and in the transport planning process at the logistics service provider were implemented to reduce the distance and time impacts of uncertainty, namely:

- A more accurate volume forecast process.
- A more dynamic scheduling and routing of deliveries.
- Early picking and sorting of products at the DCs.
- Monitoring planned against actual kilometres.

These processes reached to a settled state in July 2009. In Phase 2, after repeating the same data collection approach applied in Phase 1, a number of semi-structured interviews were undertaken with directors and managers from the logistics service provider (managing director, marketing director, operations director and operations manager) and from the customer (national transport director and transport manager) to link the uncertainty reduction achieved through the changes implemented and to investigate how the collaborative relationship between the two companies influenced on the improvements achieved. Furthermore, participant observation was applied to triangulate the data gathered during the interviews with experiential observations gathered by the researcher during Phases 1 and 2.

RESEARCH FINDINGS FROM THE LONGITUDINAL CASE STUDY

Overall, when comparing the results from the data collection exercises undertaken in Phases 1 and 2 improvements were implemented in the customer's processes which generated the need for re-planning the transport network as well as in the transport planning process executed by the logistics service provider. Table 1 shows a comparison between the overall findings gathered in Phases 1 and 2. As a result of the improvement initiatives implemented in the processes that affect the re-planning of the network, between Phases 1 and 2, the level of 'extra distance' in the network was considerably reduced from 6.7% to 0.8%. However, this could be considered an underestimate as congestion was not evaluated in Phase 1. This reduction had two main consequences in terms of performance. The first one is that the total fixed and variable transport costs generated due to uncertainty decreased from 20% to 2% of the total transport cost incurred by running the network. The second outcome is that the total CO_2 emitted due to extra kilometres travelled linked to uncertainty was reduced by 88%.

		Phase 1	Phase 2
Transport re-planning processes	Extra distance (%)	6.7	0.8
	Extra cost (%)	20	2
	Extra CO2 emissions (Tonnes)	6.7	0.8
Transport planning improvements	Estimated number of trips saved (%)	10	4
Key performance measures	Average vehicle utilisation (%)	50	70
	Volume moved per kilometre	4.63 units	4.72 units

Note: All results are calculated on a weekly basis

Table 1: Summary of the findings from Phases 1 and 2

Additionally, further improvements in the transport planning process were implemented to increase the average vehicle utilisation within the network. This initiative consists of identifying the existent opportunities for outlet delivery consolidation. As Table 8 shows, the percentage of trips found during the exercise which could potentially be saved by consolidating outlet deliveries decreased from 10% in Phase 1 to only 4% in Phase 2. This reflects the improvements shown in Table 8 in terms of the average vehicle utilisation, from 50 to 70%, and in terms of volume moved per kilometre, from 4.63 to 4.72 units. This confirms that the logistics service provider achieved the goal of making the transport planning of the network significantly tighter. Nevertheless, the customer was paramount in achieving this improvement, since the delivery windows at different outlets needed to be changed and the efficiency of the unloading process at outlets required to be increased.

Uncertainty causes reduction linked to process re-engineering initiatives

Table 2 shows a comparison between the 'extra distance' generated by the uncertainty causes identified in Phases 1 and 2 and the link between the uncertainty reduction achieved with the improvement initiatives implemented in the network. In Phase 1, the main uncertainty causes found were originated at the customer facilities. These two uncertainty causes are 'late notification of extra volume from outlets' and 'product not loaded at distribution centres'. These two causes represent 86% of the 'extra distance' generated in Phase 1 and 29% of the 'extra distance' measured during Phase 2. Furthermore, as it has already been discussed, it is important to emphasise that 'extra distance' was significantly reduced between January 2009 and Phase 2.

Uncertainty causes	Phase 1		Phase 2		Improvement initiatives implemented			
	% of 'extra distance'	Frequency (%)	% of 'extra distance'	Frequency (%)	A more accurate volume forecast process	A more dynamic scheduling and routing of deliveries	Early picking and sorting of products at the DCs	Monitoring planning against actual kilometres
Unplanned road congestion	Not captured	Not captured	71	92				X
Late notification of extra volume from outlets	44	40	20	6	X	X		
Planning failure	14	10	Not found	Not found	x			x
Product not load at distribution centres	42	50	9	2		X	X	

Table 2: Causes of 'extra distance' recorded during both phases

'Extra distance' due to late notification of extra volume from outlets was mainly originated by two root causes: inaccuracy in the volume demand forecasting process at the customer and rigidities in the scheduling and routing processes. Before March 2009, the volume demand of outlets was calculated by aggregating historical demand of outlets which were located in the same geographical area. As a result, the customer decided to re-engineer the volume demand forecast process, estimating the volume requirements per outlet by using historical demand per product range per individual outlet. This change dramatically reduced the additional trips required due to demand uncertainty.

In addition, the logistics service provider decided to make the scheduling and routing of deliveries more dynamic. The transport plan is now revised and changed weekly instead of monthly to respond to changes in geographical demand patterns. This enables the logistics service provider to accommodate to late-notice increases in volume by using space available in vehicles scheduled initially in the transport plan. These two initiatives required joint collaboration and continuous communication between the logistics service provider and the customer, since their effects on the warehousing and freight transport processes at both companies needed to be constantly monitored during the implementation and the company affected by the each change provided feedback to the entity in charge of the change.

HOW HAS COLLABORATION ENABLED THE CHANGE?

So far, a measure and an explanation of improvements achieved have been presented. As presented in Table 3, the links between the improvements achieved by the logistics triad studied are connected to the logistics collaboration elements proposed by Barratt (2004). Firstly, throughout the entire uncertainty reduction programme, the logistics service provider and the customer were driven by common objectives and priorities, namely keeping customer service levels high as well as reducing variable and fixed freight transport costs and the carbon footprint of their network. The logistics service provider has an innovative and proactive approach to process improvement, since their main focus is the customer. This logistics triad is driven by a strong process innovation culture at all levels of decision making. They set common metrics and measures to assess the impact of supply chain and external uncertainties on operations run by them and their customers. In the specific case of this case study, they have adapted the 'extra distance' and 'extra time' measures to their supply chain.

Source	Logistics collaboration elements	Case study logistics triad
Insufficient supply chain integration and trust	Plans and priorities	Common
	Customer focus	The end customer
	Supply chain metrics	Set holistically to measure the whole supply chain
	Supply chain measures	Shared between both organisations
Lack of a collaborative corporate vision	Decision-making approach	Decisions are taken at both strategic and operational levels to improve the supply chain as a whole
	Collaborative culture	Both companies collaborate at all levels. Although directors and managers from both companies take decisions jointly, there is scope to improve further, making the relationship between the companies less transactional
Insufficient monitoring and control of processes	Logistics triad members' knowledge of their partners' processes	The operations managers at both companies know their own processes well and are also well-informed of their partner's processes
	Execution of continuous improvement	All managers, directors and operators have a culture of continuous improvement.
	Scalability and measurement of performance	Performance is monitored in a daily basis at both companies and communicated to partners at all levels
Demand and information uncertainty	Effectiveness of planning and execution of promotions	Promotions are informed in advance to the logistics providers, hence the negative effects of them on transport performance can be minimised.
	Information processing capacity	In terms of information processing capacity, both companies have systems and reports to evaluate the effects of uncertainty on performance.

Table 13: Enablers of collaboration within the logistics triad studied (adapted from Barratt 2004)

As it has been mentioned in previous sections, the logistics service provider shared the findings from Phase 1 with the distribution and commercial teams at the customer and a joint process improvement plan was developed as a result thereof. All the improvements achieved by the logistics service provider and the customer were based on a strong collaborative culture at strategic, tactical and operational levels, and a comprehensive knowledge of each of the main processes within the logistics triad at both companies. As it has been explained before, a number of initiatives were applied based on the findings gathered in Phase 1. All of these initiatives required an understanding of the knock-on effects on freight transport cost of the main uncertainty causes found in Phase 1, on the reliability and responsiveness of the delivery process. More specifically, in the case of volume demand uncertainty originated at the customer side, the distribution and commercial departments at the customers required first to understand the impacts generated by this problem on processes run by them and their partners, and subsequently, they decided to make significant changes to their volume demand forecast processes. This includes the implementation of a more accurate and holistic volume demand forecast systems with better and more effective communication of additional volume demand requirements due to either product seasonality and/or promotions set between the customer commercial department and suppliers. Also, in the case of improving the efficiency of picking and sorting of products, the customer decided to engage its suppliers in order to ensure success in this initiative. Furthermore, in the case of adopting a more dynamic transport network planning process, the logistics service provider and the customer distribution department needed the complete support of the customer commercial department.

In the execution of the process improvement programme planned and executed between March and May 2009, all key personnel from the logistics service provider and the customer were monitoring and communicating continuously to each other the effects of the implementation of the initiatives on the performance of all logistics processes which could be affected by the changes. In order to do that, a joint metric system was designed and embedded into the set of supply chain measurements of both companies.

CONCLUDING REMARKS

Recently, research undertaken in logistics collaboration has primarily focused on dyadic relationships between different supply chain members (Bask, 2001). There have been a number of conceptual research works on logistics collaboration (Larson 1992, Bask, 2001, Larson and Gammelgaard, 2001 and Stefansson, 2006). Barratt (2004) has developed a framework on the barriers of logistics collaboration. However, more empirical evidences were needed to refine these conceptual works. The paper presents a longitudinal study which evaluates the importance of logistics collaboration principles applied within an exemplar South African Retail logistics triad. The findings demonstrate the importance of embedding principles of logistics collaboration for achieving world-class supply chain performance.

In addition, a number of researchers have identified supply chain uncertainty as one of the main barriers of logistics collaborations (Mason-Jones and Towill 1998, Vickery et al. 1999, Giunipero and Eltantawy 2004, Naim et al. 2006, Sanchez-Rodrigues et al. 2010a, Sanchez-Rodrigues et al. 2010b). However, there have been little empirical studies which evaluate the connections between uncertainty and inter-company collaboration in logistics environments. The study has shown how logistics service providers can contribute proactively to transport-related uncertainty reduction to achieve improvements in performance with their logistics triads

As a result of this study, a number of managerial implications have been identified. The logistics triad investigated have demonstrated how uncertainty can be jointly reduced by customers and logistics service providers. Also, the logistics service provider can be considered an exemplar case in terms of customer focus and process innovation culture. In this logistics triad, transport is a strategic activity since it brings value to the customer by ensuring products are delivered into outlets in the right quantity and at the right time, but with the lowest cost possible. The case study presented in the paper can be used as a best practice to guide improvements within road freight transport operations from other logistics triads in Retail sectors from South Africa and other countries. The generic lessons learnt in the case study can also guide other logistics triads from other sectors on how to develop and maintain an effective and sustainable collaborative logistics partnership.

Finally, the case study presented in this paper is based on data gathered in two typical weeks over an 18-month period and interviews undertaken with directors and managers from strategic and operational levels. This data compares the transport plan and execution of delivery process run in a Retail road freight transport network. The findings demonstrate the effectiveness of the improvement initiatives undertaken by the logistics triad studied. Nevertheless, a follow-up of the findings is required to verify that the levels of uncertainty found in Phase 2 are sustained in the long term. Furthermore, other longitudinal studies are required to further examine the links between uncertainty and logistics collaboration. Also, a questionnaire-based survey could be used to measure more widely the association between the variables found in this longitudinal study, e.g. logistics triad collaboration, communication, innovation, problem solving, supply chain uncertainty and performance.

REFERENCES

Barratt, M (2004), Understanding the Meaning of Collaboration in the Supply Chain, Supply Chain Management: An International Journal, 9 (1), pp. 30-42.
Bask, A. H. (2001) Relationships among TPL providers and members of supply chains – a strategic perspective. Journal of Business and Industrial Marketing, 16 (6), pp. 470-486.
Bichescu, B., Fry, M. (2009), "A numerical analysis of supply chain performance under split decision rights", Omega, 37 (2), pp. 358-379.

Childerhouse, P. and Towill, D.R. (2003), “Simplified material flow holds the key to supply chain integration”. Omega, 31 (1), pp. 17–27.
Davis, T. (1993) Effective Supply Chain Management, Sloan Management Review, Summer 1993, pp. 35-46.
DEFRA (2009), Guidelines to Defra's GHG conversion factors for company reporting, http://www.defra.gov.uk/environment/business/reporting/pdf/conversion-factors.pdf
de Swardt, A., Potter, A., Robinson, A. and Sanchez-Rodrigues, V. (2011), “Measuring ‘Extra Distance’: A case study”, in King, D. (Ed) 7th Annual State of Logistics Survey for South Africa 2010, available at http://www.imperiallogistics.co.za/csirebook/
Geary, S., Childerhouse, P. and Towill D. (2003), “Uncertainty and the seamless supply chain”. Supply Chain Management Review, July/August, pp. 52-61.
Hines, P. A. (1994) Creating World Class Suppliers: Unlocking Mutual Competitive Advantage, Pitman Publishing, London.
Larson, P. D. and Gammelgaard, B. (2001) The Logistics Triad: Survey and Case Study Results. Transportation Journal, 41 (2/3), pp.71-82.
Mason, R.; Lalwani, C.; Boughton, R. (2007), Combining vertical and horizontal collaboration for transport optimisation", Supply Chain Management: An International Journal, 12 (3), pp. 187 – 199.
Mason-Jones and Towill (1998), “Shrinking the supply chain Uncertainty Circle”. Control, September, pp. 17-22.
McKinnon, A., Edwards, J., Piecyk, M., Palmer, A. (2009), “Traffic congestion, reliability and transport performance: A multi-sectoral assessment”, International Journal of Logistics: Research and Applications, 12 (5), pp. 1-15.
Mentzer, J. T. DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D. and Zacharia, Z. G. (2001) Defining Supply Chain Management. Journal of Business Logistics, 22 (2), pp. 1-24.
Miles
Naim, M. M., Potter, A. T., Mason, R. J. and Bateman, N. (2006) The Role of Transport Flexibility in Logistics Provision. International Journal of Logistics Management, 17 (3), pp. 297-311.
Pine, B. J., II. (1993). Mass Customisation: The Frontier in Business Competition. Harvard Business School Press, Boston, MA.
Sanchez-Rodrigues V., Cowburn, J., Potter, A., Naim, M. M., (2009) Diagnosis of ‘extra distance in the UK FMCG primary transport sector, International Symposium on Logistics, Istanbul, 5th– 7th July 2009.
Sanchez-Rodrigues, V., Potter, A., Naim, M. (2010a), Evaluating the causes of uncertainty in logistics operations, International Journal of Logistics Management, 21 (1), pp. 45 – 64.
Sanchez-Rodrigues V., Potter, A., Naim, M. M., McKinnon A., and Darby J. (2010b), Measuring the time and distance impacts, Logistics Network Research Conference, Harrogate, UK, 8th-10th September 2010.
Stefansson, G. (2006) Collaborative Logistics Management and the Role of Third-Party Providers. International Journal of Physical Distribution & Logistics Management, 36 (2), pp. 76-92.
Van der Vorst J; Beulens A. (2002) “Identifying sources of uncertainty to generate supply chain redesign strategies”, International Journal of Physical Distribution & Logistics Management, 32 (6), pp. 409-427.
Vickery, S., Calantone, R. and Droge C. (1999), “Supply chain flexibility: An empirical study”, Journal of Supply Chain Management, 35 (3), pp. 16-24.
Whipple, J. S. and Gentry, J. J. (2000) A Network Comparison of Alliance Motives and Achievements. Journal of Business and Industrial Marketing, 15 (5), pp. 301-322.

SUPPLY CHAIN SECURITY 2030 – HOW SECURITY ISSUES WILL AFFECT GLOBAL SUPPLY CHAINS

Christoph Markmann[1], Tobias Gnatzy, Dr. Heiko A. von der Gracht, Dr. Inga-Lena Darkow
Center for Futures Studies (CEFU)
Supply Chain Management Institute (SMI), EBS Business School, Wiesbaden, Germany

Research Paper

INTRODUCTION

In recent years the security of supply chains has become a severe issue. Airports, hubs and critical infrastructures are becoming more and more preferred targets for attacks and sabotages compromising the stability of global supply chains. Since the main part of the increasing global cargo transport is processed by a limited number of certain gateway regions (Rodrigue, Comtois et al. 2009), which are regions embracing a comparatively high number of ports, airports and train stations in a metropolitan region, the complex network of suppliers and customers can easily be shocked. Besides these gateway regions, logistics chokepoints such as the Panama Canal, Suez Canal or the Strait of Malacca form critical 'hotspots' since they determine the most efficient routes for global trade without competitive alternatives. Therefore, they contribute to a high degree to the vulnerability of global supply chains.

Since 9/11, authorities have put great efforts on security enhancing initiatives aiming to improve security levels in travel and transport. The Customs-Trade Partnership Against Terrorism (C-TPAT) program, the Container Security Initiative (CSI), International Ship and Port Facility Security (ISPS) Code or the ISO 28000 series are just some of the numerous regulations and standards to secure global traffic and infrastructure. However, recent events such as the bomb attack in Moscow, the parcel bombs from Yemen or the piracy in the Golf of Aden show that the development of effective security concepts remains a major topic. Consequently, researchers and practitioners endeavour to develop supply chain strategies which are more robust against various types of supply chain attacks.

We contribute to current research and the development of pragmatic concepts by providing a future perspective on the topic of supply chain security. We identify relevant topics and upcoming trends in the field of supply chain security in order to determine how supply chain security has to develop in the future. Therefore, we conducted a global online-based real-time Delphi survey in which 80 security experts from 25 countries evaluated and discussed the most relevant dimensions of supply chain security represented by 14 projections, i.e. future theses. The exchange of information between experts from industry, academics, politics and associations provides valuable insights and allows drawing a profound picture of expected changes and challenges in supply chain security management.

LITERATURE REVIEW

The topic of supply chain security management is arising in both academic and practitioner literature. Consequently, the number of today's profound articles and books is quite limited. The following literature review has the aim to point out (1) the lack of a clear definition of the term and the scope of supply chain security, (2) the increasing offer of practitioner literature and (3) a missing future perspective on the topic.

So far, the terms supply chain security and supply chain risks were used somewhat interchangeably (Autry and Bobbitt 2008). Although the two topics are strongly related the focus of each remains discrete. Supply chain risk management refers to business continuity planning and considers to which extent the supply chain outcome is

[1] To correspond to (christoph.markmann@ebs.edu)

susceptible to disruptions and thereby harmful for company's overall performance (Giunipero and Eltantawy 2004; Zsidisin, Melnyk et al. 2005). Supply chain security management instead is a part of organization's supply chain risk management and embraces the prevention of theft, damage or destruction of products and assets by man-made attacks (Sheffi 2001; Closs and McGarrell 2004). Even if the current number of scientific studies and publications to the topic of supply chain security is comparatively small, the topic receives more and more attention in research (Williams, Lueg et al. 2008). Investigations are made to approach this new field of study by identifying the deficiencies of current logistics networks (Modarress, Ansari et al. 2007). Furthermore, first concepts for an appropriate supply chain security orientation in firms are conceptually developed (Autry and Bobbitt 2008; Closs, Speier et al. 2008). Autry and Bobbitt (2008) specified the topic by distinguishing four relevant fields of activity regarding supply chain security: preparation and planning initiatives, security related partnerships, organizational adaption and security dedicated communication and technology. Within their analysis of deficiencies in the different areas of supply chain security, Modarress, Ansari et al. (2007) divide the topic even more. They not only differentiate maritime, rail, road and air transportation security but also mention amongst others the role of law enforcement, security technologies and corporate security training.

Besides the more theoretic security approaches by researchers, companies and associations have started to develop practical handbooks as well as security audits in order to support companies and logistics service providers in meeting the required security regulations and improving their individual security level (e.g. (Donner and Kruk 2009). The *European association for forwarding, transport, logistic and customs service CLECAT* for instance has developed a handbook on supply chain security compliance to give a pragmatic overview of supply chain security initiatives from a European perspective (CLECAT 2010). Thereby, they aim to provide guidance for their members in an area where it is increasingly difficult to avoid losing orientation. Furthermore, the Technology Asset Protection Association (TAPA), an association of security professionals and related business partners from companies who have unified for the purpose of addressing the emerging cargo security threats, has developed security audits and certification processes in order to build trust between increasingly concerned supply chain partners (TAPA 2010). The named associations are only two examples of an increasing number of companies and organizations that are dealing with the development and the assessment of security standards in the transportation industry. However, the handbooks and guidelines seldom include research and vice versa, e.g. the two streams of literature are rather detached.

This paper contributes to the current research by investigating the identified supply chain security dimensions from the literature with a clear focus on their future development. With our survey we received valuable insights from a global panel of supply chain managers and security experts about current and expected tendencies in the topic. Thereby we are able to underline, which of the security dimensions are expected to remain critical for supply chains in the future or gain even more importance.

METHODOLOGY

To assess how the topic of supply chain security may evolve in the future, we conducted on online-based Delphi survey. Within the scope of the Delphi survey process, we asked designated supply chain security experts to evaluate the probability and desirability of occurrence of 14 future projections. In addition to that, participants were asked to evaluate projections impact on the industry if they were to occur. Furthermore, we invited the experts to provide qualitative arguments to strengthen their quantitative assessment. Thus, comprehensive expert evaluations on the future of supply chain security could be surveyed.

This research design has advantages when it comes to analyses on future developments and has already been used in prior research endeavours (e.g. Ogden, Petersen et al. 2005; Gnatzy, von der Gracht et al. 2010; von der Gracht and Darkow 2010). Moreover, the Delphi method is one of the most preferred and proliferated research methods in futures research.

Development of future projections

In order to identify the most important topics considered to significantly shape the topic of supply chain security, we closely worked together with one of the world's largest advisory companies. We activated the company's international contact network as well as our university's research network and asked the networks to nominate topics which were considered to have a driving impact on the issue of supply chain security. Thereafter, we conducted intensive desk and database research to study which factors had already been studied in our research activities.

In a next step, our research team aggregated the large amount of collected data to identify the most important factors and to prepare the data to be used in a follow-up workshop for the projection development. The topics correspond to the ones of the literature review (cf. Modarress, Ansari et al. 2007; Autry and Bobbitt 2008). However, our topics aim to be applicable for supply chains in general without focusing on any nation, industry or means of transport.

Figure 1: Process of projection development

In a subsequent workshop, our research team developed future projections, i.e. short, descriptive, and provoking propositions which describe future states. Those projections should serve the basis for the Delphi questionnaire. In order to ensure validity and reliability of our research results, our Delphi projections were assessed according to strict research guidelines. Hence, projections (1) must not include any ambiguity, (2) must not include conditional statements, (3) should not use unknown scientific or technological terms, and (4) use clearly agreed definitions (Loveridge 2002). Furthermore, we ensured that projections were not formulated too concise in order to eliminate the risk that respondents may interpret them in different ways (Salancik, Wenger et al. 1971). Besides, we aimed to make sure that the processing time to fill the questionnaire is kept as short as possible since proper consideration of a few questions was more valuable for us than the cursory evaluation of large number of questions (Mitchell 1996). Thus, we aimed to limit the number of projections to 14 which is considered to represent an optimal number in Delphi surveys (von der Gracht, Gnatzy et al. 2011). They can be categorised under the headlines: targets, sources & causes for supply chain attacks, and consequences of supply chain attacks and measures.

Real-time Delphi survey method

To achieve our research goal to assess how the topic of supply chain security may evolve in the future, we conducted on online-based, real-time Delphi survey method (c.f. Gordon and Pease 2006; von der Gracht, Gnatzy et al. 2011). Contrary to conventional, round-based Delphi surveys the real-time Delphi method allows experts to receive immediate feedback on their assessment and to correct initial evaluations in the light of new information and other experts' assessments. Thus, consensus among experts can be achieved. Furthermore, the anonymous real-time Delphi process allows experts to revise prior evaluations as often as desired. So, it assists in structuring the group communication process and in eliminating deficits arising from social pressures (Dalkey and Helmer 1963) which improves quality in assessments.

In order to participate, experts received an invitation hyperlink via email. Once clicking on the link, experts were forwarded to the Delphi questionnaire. Thereby, experts were asked to evaluate presented projection's probability of occurrence (scale ranging from 0-100%), impact on industry (5 point Likert scale), and desirability (5 point Likert scale). In addition to that, experts were motivated to provide qualitative arguments to support their quantitative evaluations in all the three dimensions. After that, experts' initial assessments were saved and feedback as well as the opportunity to revise prior evaluations were given.

Selection of Delphi panel
To identify the most appropriate experts, several approaches were pursued. First, existing contacts to experts within the research partners and our network were reviewed. Furthermore, we conducted intensive external research to identify adequate participants for our Delphi survey; we researched for experts who had published relevant research articles on the topic of supply chain security, who had held interesting speeches on conferences or who occupied high level positions in organisations related to the topic of supply chain security. Adequate experts had to expose high knowledge on the topic of supply chain security in order to ensure reliability of research results (Welty 1972; Møldrup and Morgall 2001). In total, we were able to identify more than 200 potential experts for our survey which were invited to participate. As a response to our invitation, 80 participants representing experts from academia (20%), industry (69%), and politics (11%) agreed to take part in the survey and filled out the online Delphi questionnaire.

By including such a diverse mix of supply chain security experts in our Delphi panel, we were able to achieve a multi-faceted view on the topic under consideration and to motivate a controversial discussion among experts. Besides, our panel size exceeded the minimum recommended number of 30 Delphi participants (Parentè and Anderson-Parentè 1987; Skulmoski, Hartman et al. 2007) which further increased the quality of survey results.

RESULTS
In a first step of our analysis, we studied the quantitative results of our Delphi survey in-depth. As it can be seen in following tables, we calculated mean values for the assessments for probability and desirability of occurrence as well as impact on the industry. Thus, an aggregation of research results took place. In addition to that, we studied whether convergence in experts' assessments could be observed. To do so, we studied whether the standard deviations of initial assessments decreased in comparison to final assessments. Except for projection 1, experts' assessments converged strongly which is a good indicator for the effectiveness of the Delphi process. Moreover, we calculated interquartile ranges (IQR) which are an accepted indicator for consensus measurement (Scheibe, Skutsch et al. 1975; De Vet, Brug et al. 2005). For 6 out of 14 projections, consensus among experts could be achieved. However, experts were not able to achieve consensus for 8 projections. This underlines the high controversy of the topic of supply chain security. In addition to experts' quantitative assessments, we also received large amounts of qualitative data represented by experts' qualitative arguments. In total, we received 1,220 written arguments which provide the basis for further analysis of our research results. The aggregation of the experts' arguments resulted in the findings presented in the following Table 1.

Table 1: Results of the Delphi survey

EP	Estimated probability of occurrence (metric scale 0-100%)	✓✓	Strong consensus (IQR of <= 20)
	Impact on industry, if occurred (5pt-Likert scale)	✓	Moderate consensus (IQR of 20-25)
I	Desirability of occurrence (5pt-Likert scale)	✗	Moderate dissent (IQR of 25-30)
D	Interquartile range	✗✗	Strong dissent (IQR of >=30)
IQR	Intensity of convergence (% change of mean standard deviation: first vs. final value)		
CV			

Targets, Sources & Causes					
P1: The number of attacks on supply chains has increased.	**EP**	**I**	**D**	**IQR**	**CV**
	56%	3.7	1.4	✗✗ (31)	7,21%
The number of man-made attacks on supply chains is expected to increase in the future. However, companies don’t have to panic but should increase their awareness of security issues and engage in structured risk-assessment processes and professionalize in handling of supply chain disruptions.					
P2: Logistics hubs (including ports, airports) and infrastructural nodes (bridges, narrows, channels) are preferred targets for attacks	**EP**	**I**	**D**	**IQR**	**CV**
	58%	3.9	1.2	✗ (29)	-3,96
The global trade is increasingly dependent on a certain number of critical logistics chokepoints. An attack on one of those can quickly cause enormous economic damage. Companies have to assess the role of those junctions for their business and to what extend they can contribute to decrease danger in those areas. If companies minimise the risk in their own supply chains, mutual benefits will be possible.					
P3: Targeted attacks on supply chains or hubs have destabilised the economies of some regions.	**EP**	**I**	**D**	**IQR**	**CV**
	49%	3.5	1.3	✗✗ (35)	-2,10%
Logistics hubs are the targets for attacks of the future due to their strong impact on the world economy and their media visibility. If the region is small enough that it is strongly dependent on one hub, the destruction of this hub may cause havoc. However, tight global cooperation and conjunctions of global markets are expected to force other regions to react if an affected region doesn’t have means to recover.					
P4: Cyber attacks are causing more damage to supply chains than physical attacks.	**EP**	**I**	**D**	**IQR**	**CV**
	49%	3.7	1.4	✗✗ (40)	-6,15%

Cyber attacks inducing physical damage are an increasing threat for the T&L industry. By 2030, the Logistics industry will be more vulnerable to cyber attacks due to autonomous means of transportation and grown relevance of logistics related data. Therefore, it will be necessary for companies to allocate additional efforts to secure their technologies against cyber attacks and to minimise the risk of major incidents.

P5: The number of attacks on supply chains by competitors, for example in the form of sabotage, industrial espionage or mani-pulation has increased significantly.	**EP**	**I**	**D**	**IQR**	**CV**
	30%	2.9	1.3	✗✗ (30)	-16,43%

Sabotage and industrial espionage among competitors is not a driving topic in the transport and logistics industry. T&L companies should continue to follow the trend of collaboration. However, experts are concerned about increasing attacks on their intellectual property and corporate infrastructure induced by foreign governments.

Consequences					
P6: Security has become one of the most important cost drivers for logistics.	**EP**	**I**	**D**	**IQR**	**CV**
	57%	3.5	2.2	✗✗ (30)	-2,29%

Security spending is expected to increase. However, experts point out that spending for security is more than just a cost driver. It rather yields to a positive return on investment becoming quantifiable on the balance sheet. Companies have to calculate business cases to identify how security investments can improve supply chain performance.

P7: Regional threats to security have caused shifts to transport routes.	**EP**	**I**	**D**	**IQR**	**CV**
	61%	3.6	1.9	✓ (25)	-10,24%

Transport routes will increasingly be influenced by security concerns. T&L companies will be forced to be much more flexible in their transportation routing in order to avoid certain 'hot spots' that pose problems for security in transit. Even though a shift in transport routes may effect higher transport costs and longer travel times, a more secure and reliable transport route includes numerous advantages.

P8: Concerns around data privacy are increasingly ignored in favour of greater security.	**EP**	**I**	**D**	**IQR**	**CV**
	56%	3.1	2.1	✓✓ (20)	-6,10%

Individuals will be willing to share private data if it serves security improvements. However, organisations have to learn the respectful handling of private data in order to improve their processes along the entire supply chain.

	EP	I	D	IQR	CV
P9: Additional security measures have resulted in increased transport times.	64%	3.8	1.9	✗✗ (30)	-8,61
Business models based on time-critical deliveries may be squeezed out of the market. It will be essential for companies in the future to handle security procedures effectively and efficiently to absorb higher costs and time requirements resulting from security requirements.					
P10: Supply chain complexity has been reduced due to unresolved security problems.	**EP**	**I**	**D**	**IQR**	**CV**
	30%	3.2	2.2	✓✓ (20)	-10,31%
Even if there is a tendency to make supply chains tighter and more impenetrable, their complexity is expected to increase due to adapted sourcing strategies from different countries and suppliers.					

Measures					
P11: Government institutions play the leading role in ensuring secure supply chains.	**EP**	**I**	**D**	**IQR**	**CV**
	44%	3.4	2.8	✗ (28)	-7,71%
Governments are expected to reduce their executive power and focus on their legislative roles. T&L companies consider the government's reduced role as a desired opportunity to improve their own security measures. Admittedly, companies which have to execute security standards should work together with governmental institutions to represent their own interests. Thus, security standards become not only effective, but efficient.					
P12: Using advanced technology is the best way to guarantee security.	**EP**	**I**	**D**	**IQR**	**CV**
	59%	3.5	3.0	✓ (25)	-4,90%
Technology alone will not help in a sufficient way to receive an appropriate level of security. Even though advanced technology is seen as a big lever to increase security, it is regarded as a support tool for soft science activities, as human intelligence, presence and good governance. Only in combination with consistent processes and qualified staff, technology can valuably contribute to an improved security level.					
P13: Security audits are compulsory along the whole supply chain, from raw material delivery up to point of sale.	**EP**	**I**	**D**	**IQR**	**CV**
	70%	3.8	3.4	✓ (25)	-12,52%
Security audits along the entire supply chain are a requirement to maintain effective levels of security. Companies should work together with standard setters to develop Generally Accepted					

Security Principles (GASP).					
P14: Strategies to cope with emergencies are a more effective means of dealing with supply chain disruption than preventative measure.	**EP**	**I**	**D**	**IQR**	**CV**
	44%	3.0	2.5	✓✓ (20)	-12,43%
The reactive response to supply chain disruptions will not be sufficient – organisations have to become much more preventive. Companies have to find the right combination of preventive and reactive measures to achieve the optimal level of supply chain security.					

The survey's results confirm the relevance of the determined subitems of supply chain security management from the literature (cf. (Modarress, Ansari et al. 2007; Autry and Bobbitt 2008). In addition, the numerous experts' arguments contribute to current research by assessing these subitems from a practical perspective and adding therefore valuable insights to the topic of supply chain security.

CONCLUSION

With our research we aimed to identify relevant topics regarding supply chain security and how these topics are expected to develop until 2030. By conducting intensive desk and literature research we determined the most relevant contributing factors and developed them into 14 future projections. The assessment of these future projections by our international expert panel and their extensive exchange of arguments allow us to draw a valid picture on expected challenges in the field of supply chain security 2030.

The results of the study can be summarized as follows:

- The man-made attacks on supply chains will increase until 2030. Since hubs and logistics nodes are the bottlenecks of global supply chains they are expected to be the targets of these attacks. Companies have to increase their flexibility to be less vulnerable to disruptions
- Cyber attacks and espionage will play a minor role in the context of supply chain management. However, the tendency to a more data and information based logistics industry raises concerns among experts that the relevance of these attacks may increase in the next years.
- Regional threats will cause shifts in transport routes and modes and thereby increase transport times.
- Spending on security issues will increase but contribute also to reduce companies' losses due to theft and supply chain disruptions
- Technology is the biggest lever to provide security but only in combination with appropriate processes and trained staff.
- Close collaboration is required between authorities, associations and companies in order to develop generally accepted security standards. Compulsory security audits will contribute to the compliance of these standards.

The research in the field of supply chain security management will require more attention in the next years in order to make supply chains more secure against the different ways of man-made attacks. The current research provides a first approach to relevant factors of the topic, which needs to be further investigated, coordinated and quantified by appropriate operating figures.

ACKNOWLEDGEMENTS
The authors would like to thank all Delphi participants for their valuable thoughts, visions and ideas in the Delphi survey as well as the research sponsor of the T&L2030 scenario series (www.pwc.com/tl2030) PricewaterhouseCoopers Germany, especially Klaus-Dieter Ruske, Dr. Peter Kauschke and Julia Reuter.

REFERENCES

Autry, C. W. and L. M. Bobbitt (2008). "Supply chain security orientation:. conceptual development and a proposed framework." International Journal of Logistics Management **19**(1): 42-64.
CLECAT. (2010). "CLECAT's Supply-Chain Security Compliance Handbook." Retrieved 19th of March, 2011, from http://www.clecat.org/dmdocuments/sr004osecu101201clecatscscomphandbook.pdf.
Closs, D., C. Speier, J. Whipple and M. D. Voss (2008). "A Framework for Protecting Your Supply Chain." Supply Chain Management Review **12**(2): 38-45.
Closs, D. J. and E. F. McGarrell (2004). "Enhancing security throughout the supply chain." Special Report to the IBM Center for the Business of Government.
Dalkey, N. and O. Helmer (1963). "An experimental application of the Delphi method to the use of experts." Management Science **9**(3): 458-467.
De Vet, E., J. Brug, J. De Nooijer, A. Dijkstra and N. K. De Vries (2005). "Determinants of forward stage transitions: a Delphi study." Health Education Research **20**(2): 195-205.
Donner, M. and C. Kruk (2009). "Supply chain security guide." NW: Department for.
Giunipero, L. C. and R. A. Eltantawy (2004). "Securing the upstream supply chain: a risk management approach." International Journal of Physical Distribution & Logistics Management **34**(9): 698-713.
Gnatzy, T., H. von der Gracht and I.-L. Darkow (2010). The Future of Supply Chains. 15th International Symposium on Logistics, Kuala Lumpur, Malaysia, Nottingham University Business School.
Gordon, T. and A. Pease (2006). "RT Delphi: An efficient, "round-less" almost real time Delphi method." Technological Forecasting and Social Change **73**(4): 321-333.
Loveridge, D. (2002). On Delphi questions. Ideas in Progress. Manchester, The University of Manchester.
Mitchell, V. (1996). "Assessing the reliability and validity of questionnaires:..." Journal of Applied Management Studies **5**(2): 199-207.
Modarress, B., A. Ansari and D. Lockwood (2007). "RAISING THE ALARM FOR LOGISTICS NETWORK SECURITY." International Journal of Business Research **7**(5): 221-225.
Møldrup, C. and J. M. Morgall (2001). "Risks of Future Drugs: A Danish Expert Delphi." Technological Forecasting and Social Change **67**(2-3): 273-289.
Ogden, J. A., K. J. Petersen, J. R. Carter and R. M. Monczka (2005). "Supply Management Strategies for the Future: A Delphi Study." Journal of Supply Chain Management **41**(3): 29-48.
Parentè, F. J. and J. K. Anderson-Parentè (1987). Delphi inquiry systems. Judgemental Forecasting. G. Wright and P. Ayton. Chichester, John Wiley & Sons**:** 129-156.
Rodrigue, J. P., C. Comtois and B. Slack (2009). The geography of transport systems, Taylor & Francis.
Salancik, J. R., W. Wenger and E. Helfer (1971). "The construction of Delphi event statements." Technological Forecasting and Social Change **3**(5): 65-73.
Scheibe, M., M. Skutsch and J. Schofer (1975). Experiments in Delphi Methodology. The Delphi Method - Techniques and Applications. H. A. Linstone and M. Turoff. Reading, Addison-Wesley**:** 262-287.
Sheffi, Y. (2001). "Supply Chain Management under the Threat of International Terrorism." International Journal of Logistics Management **12**(2): 1-11.
Skulmoski, G. J., F. T. Hartman and J. Krahn (2007). "The Delphi Method for Graduate Research." Journal of Information Technology Education **6**: 1-21.

TAPA. (2010). Transported Asset Protection Association Retrieved March 19th, 2011, from http://www.tapaemea.com/public/certification_dir.php?navId=4&subnavId=1.
von der Gracht, H. A. and I.-L. Darkow (2010). "Scenarios for the logistics services industry: A Delphi-based analysis for 2025." International Journal of Production Economics **127**(1): 46-59.
von der Gracht, H. A., T. Gnatzy, I.-L. Darkow, T. J. Gordon and J. C. Glenn (2011). New Frontiers in Delphi Research – Experiences with Real Time Delphi in Foresight. Conference Volume of the WorldFuture 2011, Vancouver.
Welty, G. (1972). "Problems of selecting experts for delphi exercises." Academy of Management Journal **15**(1): 121-124.
Williams, Z., J. E. Lueg and S. A. LeMay (2008). "Supply chain security: an overview and research agenda." International Journal of Logistics Management **19**(2): 254-281.
Zsidisin, G. A., S. A. Melnyk and G. L. Ragatz (2005). "An institutional theory perspective of business continuity planning for purchasing and supply management." International Journal of Production Research **43**(16): 3401-3420.

RISK CONTROL AND COLLABORATION IN MARITIME SUPPLY CHAINS

Jyri Vilko, Jukka Hallikas
School of Business, Lappeenranta University of Technology
FI-53851, Lappeenranta, Finland
Jyri.Vilko@lut.fi, Jukka.Hallikas@lut.fi

1 INTRODUCTION

Supply chain complexity and disintegration are emerging as major challenges in supply chain risk management (Waters, 2007). As logistic operations are getting divided between an increasing number of operators, organisational responsibilities relating to risk management are becoming hazier. The phenomenon can be seen to occur not only in the private but also in the public sector. The ability to identify risks decreases as the visibility in the supply chain diminishes beyond the organisation's own functions. The risks and their visibility and control depend on the position of the companies in the supply chain and on the level of analysis they are able to carry out.

With an increasing number of functions acquired from outside service providers, companies' dependency on them keeps increasing (Tuncel and Alpan, 2010). From the viewpoint of security of supply, national and international dependency on private companies has grown during the last decades as governments have sold their ownership in a number of companies. Therefore, the role of state authorities has shifted from emergency transport provision and stockpiling of goods towards securing supply chains and the position of private companies in them in all circumstances. The roles of these publicly and privately owned organisations are, therefore, closely interconnected and require collaboration and information exchange to ensure functional risk management.

Supply chain risk management has a great influence on the stability of dynamic co-operation among supply chain actors and is hence very important for efficient supply chain operations (Xia and Chen, 2011; Lambert et al., 1999). Studies on collaboration in the recent scientific literature are typically limited to business partners, that is, private firms. However, the public sector has an important role in supply chain risk management, as they pursue to secure the fluent and uninterrupted flow of goods and information in the chains. In order for the supply chain to manage risks properly, the members that have the most control over the risks have to be identified.

In this paper, we present preliminary research concepts for identifying the most important actors in the supply chain from the risk management perspective as well as risk management control approaches between supply chain members in a case supply chain between the Gulf of Finland and inland Finland. The main aim of this study is to illustrate the identification and controlling of supply chain risks by the private and public actors in the chain. A network analysis is conducted to illustrate the relationships and centrality of different actors in supply chain risk management. The study is based on the literature on supply chain risk management and the findings from interviews and expert sessions conducted.

2 SUPPLY CHAIN RISK MANAGEMENT

Increasing risks in the supply chain are a current trend in logistics (Minahan, 2005). The literature on supply chain management usually defines risk in purely negative terms, and as leading to undesired results or consequences (Harland et al., 2003). A standard formula for the quantitative definition of supply chain risk is

$$\text{Risk} = P(\text{Loss}) * I(\text{Loss}),$$

where risk is the probability (P) of loss and the significance of its consequences (I) (Manuj and Mentzer, 2008).

Managing risks requires better understanding of them (Hallikas et al., 2004; Faisal et al., 2006), and at the core of supply chain risk management is the activity of identifying the risks (White, 1995; Sinha et al., 2004; Waters, 2007; Rao and Goldsby, 2009). Risk identification and analysis in a supply network is a complex and holistic phenomenon and a comprehensive analysis contains a variety of methods that are used simultaneously (see Harland et al., 2005). The control of supply chain operations is one of the key factors in supply chain risk management (Christopher and Lee, 2004). The control over operations allows the mitigation of the identified risks. However, without the ability to identify and assess the risks, it has little meaning, and this is where supply chain collaboration is of the essence.

Supply chain collaboration means the co-operation of participating members along the supply chain to improve performance (Bowersox, 1990). In the scientific literature, supply chain collaboration is typically defined as two or more chain members working together to create a competitive advantage through sharing information, making joint decisions and sharing benefits which results in a greater probability of satisfying end-customer needs than acting alone (Simatupang and Sridharan, 2005). The most common benefits expected of collaboration are revenue enhancements, cost reductions and operational flexibility to cope with high demand uncertainties (Fisher, 1997; Simatupang and Sridharan, 2005). Increasing collaboration, however, can have its downsides as too many suppliers may make it very difficult to maintain stable relationships; therefore, it is essential to identify the actors that possess the best risk visibility and control in the supply chain.

The role of state authorities in the supply chain context is typically related to securing its operations. The concept of *security of supply* defined by the Finnish National Emergency Supply Agency (NESA), describes the goal as follows: the security of supply means "the capacity to maintain the basic activities that are indispensable for safeguarding the population's living conditions, for sustaining the functioning of critical infrastructures, and the material preconditions for maintaining national preparedness and defence in case of serious disturbances and emergency situations." Ensuring capacity and delivery are thus the key elements. In highly disintegrated and specialised supply chains this means safeguarding the livelihood of the companies involved. Some of the current security reports take this into consideration (i.e. Willis and Ortiz, 2004; Kwek and Goswami, 2003) with reference, for example, to the costs and vulnerabilities of multimodal transportation, but suggest further research on the system risk involved.

3 EMPIRICAL STUDY AND METHODS

In this study, the aim was to investigate how risks faced by the supply chain are managed by the network of private practitioners and public actors. The case maritime supply chain is located in Europe and extends from the Baltic Sea region to the Finnish mainland. The research process involved two main stages: In the first stage the operational environment and the focal supply chain were discovered by qualitative interviews with 27 managerial practitioners and a literature review of the related project reports and scientific publications. In the second stage, seven handpicked individuals with best possible knowledge over the operations and risks in the supply chain studied were chosen and invited to join expert panel discussion.

The qualitative interviews during the first phase of the empirical research process identified the uncertainties in the supply chain. In qualitative research, the subjects are studied in their natural settings in a real-life context. Given that neither the phenomenon nor the context was evident, this approach was considered appropriate in terms of making sense of the phenomena by interpreting the meanings people attach to them (Yin, 1989). It was also assumed that the qualitative approach would best serve this research purpose because it facilitates an in-depth and detailed study of the phenomenon from the interviewees' perspective. It typically entails no prior hypothesis setting, and the researcher should have no prior assumptions. (Voss et al., 2002) Sampling is generally discretionary, but the numbers may be small and the results not necessarily of statistical value.

The interviews, which were semi-structured, focused on supply chain risks and their impacts, and a discovery-oriented approach was used in order to tap into the professionals' experience and knowledge (Zaltman et al., 1982; Yin, 1989). The style was discursive, and there were no predetermined response options. Themes and questions were discussed at random to enable a natural conversational style and follow the interviewees' lead. In order to obtain a holistic view of the operations, the interviewees were asked to describe their own activities in the case supply chain and to take into account the processes on a broader level. The aim was to focus on the process in order to determine what factors influenced the chain and what kind of risks were involved in the different stages.

The interviewees were selected from the actors best representing their field and with a high significance to the area of operations. All the contributing actors were operating in different parts of risk management in the supply chain studied, representing road, rail and maritime transportations, port administrators, port operators, insurance companies, international logistics operators, defence forces, border guards, a national transport agency, a ship owners' association and the National Emergency Supply Agency. The interviewees had a range of duties related to supply chain and risk management. They varied in terms of position, but all had an extensive understanding of their company's operations. It was considered essential for them to have a wide perspective on supply chain operations and risks in order to ensure accuracy in the analysis.

After the interview process, an expert panel session involving seven individuals was conducted with both private and public actors. The participants of the expert session were those that were identified by the interviewees to hold the best possible knowledge of the research subject. The purpose was to verify and analyse the interview data and finally to determine the risks and their control capabilities among the supply chain members. The interviewers set up the sessions, and their role was to present the preliminary findings and guide the discussion in a holistic direction. The panel comprised private actors in the logistics field as well as public actors responsible of securing the focal supply chain.

The session was organised by utilising an Information Technology (IT) -based groupthink software system where the participants are connected to a common IT platform. The participants were physically in the same place because we wanted them to share their ideas on the topic with the group. The formal process that followed included the generation of ideas (brainstorming) and evaluations in a group. The participants were able to generate ideas and assessments anonymously, so that other participants were not able to identify the source of the idea or comment inserted into the system. All participants were able to see the ideas that other participants had generated anonymously online.

4 RISK IDENTIFICATION AND ANALYSIS

The risks seen by the supply chain practitioners varied among the actors and their background, but many of the risks were also identified by several actors. The transport supply chain process map was created to identify the risks associated with the maritime supply chain under investigation based on the interviews. The identified risks are presented in Table 1.

	Likelihood	Impact	Risk	%
Supply risks				
Supply of raw materials	2.0	4.2	8.4	3.5%
Lack of transportation equipment	1.8	3.2	5.8	2.4%
Damaged transportation infrastructure	1.6	2.4	3.8	1.6%
Damaged goods during transportation	2.4	2.8	6.7	2.8%
Delivery delayed	2.2	2.8	6.2	2.6%
Possibility to gain access to the information in the SC	2.8	2.6	7.3	3.0%
Security risks				
Unknown actor in the supply chain	2.0	2.8	5.6	2.3%
Pandemic	1.4	3.4	4.8	2.0%
Neglecting maintenance	2.0	3.2	6.4	2.7%
Organised crime	1.6	4.0	6.4	2.7%
Exceptional circumstances	2.6	3.4	8.8	3.7%
Hazardous materials	2.0	3.8	7.6	3.2%
Terrorism	1.0	4.2	4.2	1.7%
Oil spill	2.0	4.0	8.0	3.3%
IT systems security	3.0	3.8	11.4	4.7%
Operational risks				
Non-specific instructions	2.6	2.8	7.3	3.0%
Bad communications	2.8	2.6	7.3	3.0%
Strike	3.0	4.0	12.0	5.0%
Lack of needed materials	1.2	4.0	4.8	2.0%
Equipment breaks	2.4	2.8	6.7	2.8%
IT system failures	2.6	3.6	9.4	3.9%
Demand risks				
Lack of demand	2.4	3.2	7.7	3.2%
Rapid growth and demand of sea transportations in the Baltic Sea Reg.	1.6	3.0	4.8	2.0%
Increase in transportation costs	1.6	2.2	3.5	1.5%
Macro risks				
Economic recession	2.6	3.8	9.9	4.1%
Lack and high prices of fuel	2.4	3.2	7.7	3.2%
Imbalanced import and export	2.2	3.0	6.6	2.7%
Policy risks				
Lack of skills and know-how	2.4	3.4	8.2	3.4%
Carelessness	2.8	3.4	9.5	4.0%
Attitude problem	2.6	3.4	8.8	3.7%
Resistance to change	2.8	2.8	7.7	3.2%
Other risks				
Distrust and unfamiliarity of other actors	2.6	3.2	8.3	3.5%
Internationality	3.4	2.6	8.8	3.7%
TOTAL	74.4	107.6	240.4	100%

Table 1. Identified risks and their analysis

The risks identified by the supply chain private and public actors were mostly the same, however, some differences were also found. The ability to identify risks varied highly among the interviewees. Typically, a lower level of knowledge appeared in the smaller logistic companies, which did not have clear risk management at all, but rather responded to the risks case by case as they occurred. In larger logistic companies that had a global supply chain in their control, the importance of supply chain risk management was implemented on a higher level by using strategic management tools, such as modified Failure Mode Effect Analysis which clearly helped to identify risks. State officials, such as the defence forces and the border guard clearly had their own viewpoint to risks which was surprisingly strongly confined to the organisation or department of origin; however, overall their viewpoint broadened the supply chain risk management perspective.

A surprising point was the poor state of preparedness that many private companies had for any disruptions and how little collaboration there was between the organisations operating in the same supply chain. In most cases, the parties only collaborated and communicated to the extent that was compulsory or necessary in order to conduct business. However, the state officials overall seemed to be quite open to collaboration with private companies.

The risk that public actors identified to be the most important one and that also private companies saw as being among the most significant ones, is the power of the labour union (of stevedores and truck drivers) to call a strike as can be seen from Table 1. This risk also came up in every interview. The actions of the trade union had even prevented inter-functional co-operation between the companies of the supply chain, which illustrates the complexity of the relationships and risks as well as the attitude of the operational environment towards developments in the supply chain.

The vulnerability of IT systems was recognised especially by the state officials, who saw it as a high security risk. From the private companies' perspective, the information risks were seen significant as well. If there was a breakdown in the supply chain information system, the effects could be significant, and as the vulnerability of such systems is great as well, it was seen as one of the most important risks.

The increasing internationality of the supply chains was identified as a risk by the state officials as it was seen to bring unknown actors and negative side-effects to the area. Ice conditions seemed to cause problems to almost every company in the winter; however, this was not necessarily identified as a risk by the company but another member of the supply chain that had a different perspective on the processes. The public actors did not identify this as a high risk; however, when asked about their most important network members, ice breakers were mentioned as one.

5 RISK CONTROL

As risk control is one of the most essential parts of risk management, the expert group was asked to identify the most essential actors and their control capabilities of the focal supply chain. The most essential risk management actors in the supply chain were identified to be the state officials, port administration, trucking companies, port operators, shipping companies and stevedores. The risk control possibilities of those actors were valued with the group decision platform on the scale of 0 to 5, zero meaning no control over the risks and 5 meaning total control of the risks. The results are analysed in Table 2. In the analysis, security risks were considered to be the most controllable risks (16.6%) with the state officials having the highest level of control over them (3 out of 5). Other risks (representing internationality and distrust between the actors) was given the lowest controllability score by the expert session. Surprisingly, the shipping company was found to have the most control over the risks (18.6%), whereas stevedores had the least control (14.2%). The ability of the state officials to control security risks stood out compared to other values, which illustrates how collaboration would benefit the other actors.

Risk Control	State officials	Port administ.	Trucking comp.	Port operat.	Shipping companies	Stevedores

Supply risks	2	1.5	2	1.5	2	1.5	15.2%
Security risks	3	1.5	1.5	2	2	1.5	16.6%
Operational risks	1.5	1.5	2	2	2	1.5	15.2%
Demand risks	1.33	1.33	1.67	1.67	1.67	1.33	13.0%
Macro risks	1.33	1.33	1.67	1.67	1.67	1.33	13.0%
Policy risks	1.67	1.33	2	2	2	1.67	15.4%
Other risks	1.5	1.5	1	1.5	1.5	1	11.6%
	17.8%	14.4%	17.1%	17.8%	18.6%	14.2%	100%

Table 2. Risk control between the actors

6 SUPPLY CHAIN COLLABORATION

To study the collaboration further, the expert session participants were asked to describe the risk management collaboration in the supply chain. The session seemed to provide a solid method for collecting the required group-think on the phenomena being studied. In order to study collaborative actions in the case supply chain, we mapped each relationship in a supply chain risk management actor network. The strength of the tie was coded as 0 = non-existing, 1 = low, 3 medium, or 9 = high. The group evaluated the tie strengths based on the intensity of information sharing in risk management. A visual presentation of the network is provided in Figure 1.

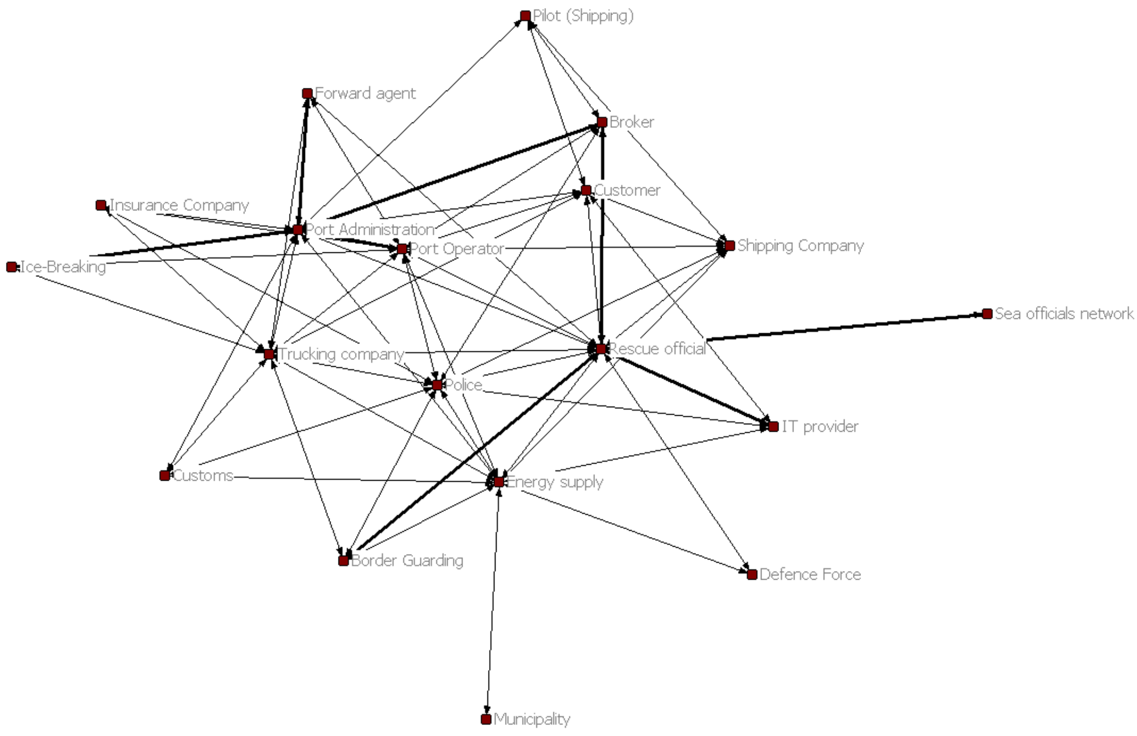


Figure 1. Actors and ties in a risk management network

As shown in Figure 1, the connections between actors are rather dense, even though the weakest ties (ties under 3) have been filtered from the graph. Also, the actors positioned beyond the core networks have an important role in the whole supply chain risk management system. For example, the sea officials' network enables formal and informal connections between the network actors. However, it is not necessarily visible in operative risk management actions.

	Degree Centrality		Betweenness Centrality
Rescue official	63	Energy supply	35.612
Port Administration	60	Rescue official	25.229
Port Operator	41	Port Administration	8.036
Energy supply	39	Customer	7.129
Trucking company	35	Trucking company	6.252
Police	33	Police	5.719
Broker	29	Port Operator	5.395
Customer	28	Pilot (Shipping)	1.829
Forward agent	21	Forward agent	0.2
IT provider	20	IT provider	0.2
Shipping Company	19	Broker	0.2
Border Guarding	19	Shipping Company	0.2
Pilot (Shipping)	18	Sea officials' network	0
Ice-Breaking	17	Customs	0
Customs	14	Border Guarding	0
Insurance Company	14	Defence Force	0
Sea officials' network	9	Municipality	0
Defence Force	6	Ice-Breaking	0
Municipality	3	Insurance Company	0

Table 3. Centralities of actors in a network

In Table 3, we summarise the actors' network positions in a case risk management network based on the tie strengths between them. Two measures, that is, degree centrality and betweenness centrality, were used to calculate the actors' centrality in the network. From the social network analysis perspective, nodes (actors) that have many ties with other nodes (actors) are the central ones. Degree centrality was used to measure the number of ties an actor has with other actors in the network. The other centrality measure used is Freeman's betweenness centrality. It assigns measures to the nodes based on their position between separated clusters of "gatekeepers" in the network.

Based on the analysis, the rescue official, port administration and port operator scored highest in degree centrality. These actors have the highest number of ties with other actors in the network. Energy supply, the rescue official and port administrator had the highest betweenness scores. This indicates a powerful role between the groups of actors in a network. The results shown are a bit surprising, although it is quite logical that public actors have a strong position in the network. Collaboration and information exchange between the actors is crucial in risk situations. As has been shown, the network of actors is quite large and all actors are needed in the risk management system.

7 DISCUSSION AND CONCLUSIONS

The main objective of this study was to identify and assess the risks and risk management in the Gulf of Finland cargo flows. The chosen research approach was threefold, as it investigated the risks involved, the relationships between individual actors and their ability to control the risks, and furthermore provided a holistic view of the focal supply chain. The risks were seen differently in each company even if many of the concerns were shared also. The level of risk management varied greatly between the organisations interviewed in the focal supply chain. The risks to the supply chain were not recognised by many of the smaller companies, as the global logistic operators clearly seemed to benefit from the visibility of the chain. Also, the conceptual understanding and comprehension of the risks varied greatly among the interviewees and many of the interviewees responded with explanations of cause and effect.

The risks identified as the most severe ones, IT systems and strikes, affect the entire chain and may occur in most parts of the chain; they would, therefore, benefit the most from collaboration. The most vital parts of the supply chains from the Gulf of Finland in the eyes of the companies interviewed were the port infrastructure and the land routes near the ports. Typically, ports are specialised to handle only some transportation modes and therefore are not easily replaced if they are disrupted. The routes in and out of the ports were seen as the most vulnerable part of the infrastructure after electricity and IT outage. The expert session that also involved state authorities listed internationality, human factors and economic recession as the greatest threats.

This study illustrates the significance of collaboration in the supply chain context, as the visibility of the risks and their control mechanisms do not necessarily involve the same actor. In such cases applying a holistic risk management perspective between private and public actors would bring benefits, as the visibility of the supply chain could enable more effective management. The supply chain's risk management control analysis makes it obvious that both the private companies that act in the supply chain and public actors have their own strong points in managing the risks and great differences in their capabilities to control different types of risks. The network analysis, on the other hand, illustrates that state officials still have a central role in and many connections with the risk management of a supply chain that is formed mainly of private companies.

Many of the risks facing the supply chains could be mitigated by collaboration and proper supply chain risk management. Some of the companies had made attempts to introduce collaboration but the lack of trust seemed to prevent deeper involvement which in most cases failed to extend beyond the necessary level hindering closer collaboration and information sharing. Practitioners will benefit from the current study as its helps them to better understand the value of supply chain risks and their assessment. Further studies are required to understand all the benefits of increased collaboration.

The illustrated method where the supply chain risks are examined from the viewpoint of the actors' control capabilities and collaboration in the supply network can give valuable insights into supply chain risk management. The social network analysis method provides an analytical and visual modelling method for identifying the structure of the risk management network, and actors' power position in the network based on the structure and strength of actor ties. The analysis can, for example, suggest planning the information flows between actors and allocating resources for risk management. Above all, network analysis promotes a holistic inquiry of actors' roles in a collaborative supply chain network and strengthens the joint risk management plan.

The viewpoint adopted and the methods used will enhance current research and arouse more discussion. The approaches to risk control adopted in the study rely on the expert knowledge of a few individuals and on subjective assessment. The case study method therefore imposes limitations. The study also has limitations in terms of its generalisability, given the size of the sample and the subjective nature of the data. There is, thus, need for further empirical research employing a more extensive data set, or a comparative study involving some other geographical location.

REFERENCES

Al-Mudimigha, A.S., Zairib, M. and Ahmedc, A.M.M., (2004), "Extending The Concept Of Supply Chain: The Effective Management Of Value Chains", *International Journal Of Production Economics,* Vol. 87 No. 3, pp. 309–320.

Blackhurst, V. J., Scheibe, P. K. and Johnson, J. D., (2008), "Supplier risk Assessment and monitoring for the automotive industry", *International Journal of Physical Distribution & Logistics Management* Vol. 38 No. 2, pp. 143-165.

Bowersox, D.J. (1990), "The strategic benefits of logistics alliances", *Harvard Business Review*, Vol. 68 No. 4, pp. 36-43.

Caridi, M., Crippa, L., Perego, A., Sianesi, A. and Tumino, A., (2010), "Do virtuality and complexity affect supply chain visibility?", *International Journal of Production Economics*, Vol. 127, No. 2, pp. 372-383.

Chuang, P. T. (2002), "Combining Service Blueprint and FMEA for Service Design", *The Service Industries Journal* Vol. 27, No. 2, pp. 91–104.

Christopher, M. and Lee, H. (2004), ”Mitigating supply chain risk through improved confidence”, *International Journal of Physical Distribution & Logistics Management,* Vol. 34 No. 5, pp.388-396.
Fisher, M.L. (1997), “What is the right supply chain for your product?”, *Harvard Business Review*, Vol. 75 No. 2, pp. 105-16.
Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V.-M., Tuominen, M. (2004), ”Risk management processes in supplier networks”, *International Journal of Production Economics* Vol. 90, No. 1, pp. 47–58.
Harland, C., Brenchley, R. and Walker, H. (2003), ”Risk in Supply Networks”, *Journal in Purchasing and Supply Management,* Vol. 9, No. 2, pp. 51-62.
Jüttner U, Peck, H. and Christopher, M. (2003), ”Supply chain risk management: Outlining an agenda for future research”, *International Journal of Logistics: Research and Applications,* Vol. 6, No. 4, pp. 197-210.
Jüttner U (2005), ”Supply chain risk management: Understanding the business requirements from the practitioners perspective”, *International Journal of Logistics Management*, Vol. 16, No. 1, pp. 120-141.
Kwek, K.-H. and Goswami, N. (2003), *Cost and Productivity Implication of Increased Security in Sea Trade Processes*, The Logistic Institute – Asia Pacific National University of Singapore. Research White Papers.
Lambert, D.M., Emmelhainz, M.A. and Gardner, T.J. (1999), “Building successful partnerships”, *Journal of Business Logistics*, Vol. 21 No. 1, pp. 165-181.
Manuj, I. and Mentzer, J. (2008), ”Global supply chain risk management”, *Journal of Business Logistics*, Vol. 29 No. 1, 133-155.
Mentzer, J., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, C. and Zacharia, Z. (2001), ”Defining supply chain management”, *Journal of Business Logistics* Vol. 22 No. 2, pp. 1-24.
Minahan, T. (2005), *The Supply Risk Benchmark Report*, Aberdeen Group, Boston, MA.
Petersen, K.J., Ragatz, G.L. and Monczka, R.M., (2005), ”An Examination Of Collaborative Planning Effectiveness And Supply Chain Performance”, *The Journal Of Supply Chain Management* Vol. 41 No. 2, pp. 14–25.
Peck, H. (2005), ”Drivers of supply chain vulnerability: an integrated framework”, International *Journal of Physical Distribution & Logistics Management* Vol. 35 No. 4,pp. 210-232.
Rao, S. and Goldsby, T. (2009), ”Supply chain risks: a review and typology”, *International Journal of Logistics Management* Vol. 20 No. 1, pp. 97-123.
Singhal, V., Hendricks, K. and Zhang, R. (2009), ”The effect of operational slack diversification, and vertical relatedness on the stock market reaction to supply chain disruptions*”, Journal of Operations Management* Vol. 27, pp. 233-246.
Simatupang, T. M.,and Sridharan, R. (2005), "The collaboration index: a measure for supply chain collaboration", *International Journal of Physical Distribution & Logistics Management*, Vol. 35 No. 1, pp.44-62.
Smaros, J., Lehtonen, J. M., Appelqvist, P. and Holmstrom, J. (2003), ”The Impact Of Increasing Demand Visibility On Production And Inventory Control Efficiency”, *International Journal Of Physical Distribution & Logistics Management* Vol. 33 No. 4, pp. 336–354.
Tang, C. (2006), ”Perspectives in supply chain risk management” *International Journal of Production Economics,* Vol. 103, No.2, pp.451-488.
Tuncel, G. and Alpan, G. (2010), “Risk assessment and management for supply chain networks: A case study”, *Computers in Industry*, Vol. 61, No. 3, pp. 250-259.
Voss, C., Tsikritsis, N. and Frohlich, M. (2002). Case research in operations management. International Journal of Operations & Production Management, Vol. 22, No. 2, pp. 195-219.
Waters, D. (2007), *Supply chain risk management: Vulnerability and resilience in logistics*, Kogan Page Limited.
Willis, H. and Ortiz, D. (2004), *Evaluating the Security of Global Containerized Supply Chain*, TR214, Santa Monica, CA: RAND Corporation.

Xia, D. and Chen, B. (2011), “A comprehensive decision-making model for risk management of supply chain”. *Expert Systems with Applications*, Vol 38, No 5 pp. 4957-4966.
Yin, R. (1989), *Case study research: Design and methods*, Thousand Oaks, CA, Sage.
Zaltman, G., Lemansters, K. and Heffring, K. (1982), *Theory construction in marketing: some thoughts on thinking*, New York, Wiley.
Zsidisin, G.A. (2003), Managerial perceptions of supply risk, Journal of Supply Chain Management, Vol. 39, No. 1, pp. 14-25.

FUTURE TRENDS ENVISAGED IN SUPPLIER RELATIONSHIP MANAGEMENT: PERSPECTIVES FROM PRACTITIONERS

Festus Olorunniwo[1], Joel Jolayemi[1], Chunxing Fan[1] and Xiaoming Li[1]
[1]Department of Business Administration, Tennessee State University, Nashville TN. USA

ABSTRACT
As the supply chains become more global and complex, companies face several current and future challenges in implementing their supplier relationship management (SRM) programs. This paper focuses on some of the future challenges (or trends) of SRM from the perspectives of the senior managers and executives. Interviews conducted with several company senior managers and executives regarding their current SRM practices provide the information used in this paper, which summarizes what the practitioners perceive, expect or desire would define the future practices in SRM.

KEYWORDS: Supplier Relationship Management (SRM), Multi-tier Supply Network, Supply Chain Risk, Collaboration in Supply Chains, Future of SRM

INTRODUCTION
Supplier Relationship Management (SRM) is defined as a way of working with the critical and strategic suppliers to systematically identify opportunities to reduce cost, improve service, improve quality, and to innovate (Carter, 2010). The definition points to the need for interactions with one's suppliers. The objective for maintaining such interactional relationship with suppliers is to ensure the continuity of the supply of high quality products or services within the multi-tier levels of supply chain.

Supply chains have become very complex. A typical original equipment manufacturer (OEM), for example, may have hundreds or thousands of tier-1, tier-2…and so on… suppliers. Thus, the ability to achieve SRM objectives in this situation is fraught with uncertainty and risk. Risk mitigation in the supply flow as well as timeliness and quality of supply has been a challenge even among the tier-1 suppliers alone. The complexity of multi-tier suppliers increases this problem a great deal, as any failure in the supply flow from any critical lower tier supplier may spell doom for the entire supply chain. Thus, companies are seeking ways to mitigate this risk by a host of methods that engender lower tier visibility through their supplier relationship management.

Although most companies seek SRM as a goal, the reality is that most firms do not implement it fully necessary to achieve the desirable goals and objectives of SRM. The reason for this failure can be attributed to the challenges, present and future, posed by a full-scale implementation. The future trends for SRM practice are as daunting as the present challenges faced. This paper attempts to highlight some of those trends and prospects as seen from the perspectives of SRM senior managers and executives. Therefore, the purpose of this report is to provide a summary of the information gleaned from interviews with several companies regarding their current SRM practices especially the trends and prospects they anticipate facing.

The paper is structured as follows. The summary of the trends and prospects cited is provided first. The next section of the paper addresses each trend one at a time starting, where necessary, with illustrative quotes from the interviewees and followed by the implication to SRM implementation. As promised, we keep the sources of the quotes confidential.

METHODOLOGY
The research team contacted and interviewed teams of SRM executives/senior SRM managers from fifteen companies. The companies that were selected for the interview come from a range of sectors (healthcare, technology, services, consumer goods, industrial goods, to mention a few). In size, included are fortune 100 -500 companies

with global operations. Two of the interviews were conducted 'face-to-face'. The others were through telephone conferencing. Some companies presented more than one person for the interview. Each interview lasted an average of one hour. Depending on the interviewees' permissions, some interviews were recorded on tape. Because strict confidentiality was promised in each case, the actual names of the companies will not be disclosed in this paper. We asked interviewees to project what trends they perceive would take place or they would like to take place in SRM practices. While one would expect that each company's response would reflect the relative preference dictated by the forces prevalent in its industry, the responses in general manifest some level of striking commonality.

FINDINGS: TRENDS AND PROSPECTS IN SRM PRACTICE

We provide below, in each subheading, an abbreviated rendering of what the company interviewees stated are the future trends expected in SRM practice. The exact descriptions are close to the verbatim rendering in the interviews so that what we state blow captures the essence of what the interviewee said. Following the summary, we provide discussions (importance and relevance) of most of the issues raised.

Holding suppliers (and their suppliers) accountable on key metrics agreed upon

> What the Companies Say (e.g. Company G, Company O)
>
> 1. "*We will continue to hold our suppliers accountable on the key measures mentioned earlier. We expect our suppliers to hold their suppliers on the same level as well.*"
>
> 2. *"As part of our supplier rating (report card) that we send out quarterly, whenever a supplier has failed to meet expectations after corrective action was in place, we would block them from getting any more orders."*

Suppliers are key value chain participants – they affect a firm's total performance. It is therefore not surprising that practitioners would hold their suppliers accountable for their performance. In particular, relationships with suppliers are critical in maintaining a competitive edge in lean organizations. Good supplier measurement systems allow companies to improve quality, move toward just-in-time production, and dramatically reduce both order cycle times and inventory costs (Doolen et al, 2006). It is expected that more and more companies would want to specify key metrics expected of their suppliers. In this regard, we would expect that such metrics be specified through the use supplier scorecard.

Use of supplier scorecard would enable the evaluation of suppliers against key critical metrics. The supplier also benefits from having these metrics outlined in the scorecard. It would enable the supplier to link its own internal performance measures with the strategic objectives of the customer. It also allows the supplier to identify opportunities to improve their performance so that they are better able to meet their customer requirements (Doolen et al, 2006). In other words, both the OEM and the suppliers will 'tighten their belts' through a well established accountability process, not only for their suppliers, but also for themselves.

Rizza (2006), citing a study by the AMR Research group, identified another problem. The study found that:

> "Although the majority of suppliers receive scorecard information, more than 50 percent of them only review their scorecards within their sales account teams or in various pockets of their organizations as needed. The majority of companies do not utilize this information either internally or externally to collaboratively enhance the value of their supply chain."

With the majority of companies not using their customer's KPI data/scorecards, accountability enforcement gap exists. The future of SRM should tolerate less and less of such gap. In the future, leading suppliers would need to utilize their scorecard data to make their supply chains demand-driven. These companies would have to focus on the final customer's demand requirements, share their ideas, and collaborate to achieve the best value for both their business and their customer's business, Rizza (2006).

Development of self-service model – data managed/driven from same 'location; standardization of supply chain systems; and making the selection process robust to eliminate risk

What the Companies Say (e.g. Companies C, E, G, and J

1. *"The first company that can come up with a self service model where all data is managed and driven to the same place to be used in a data format from a measurement standpoint it is going to do very well."*
2. *"…. to make the selection process robust to eliminate risk."*
3. *"…… information could be automatically obtained like the way FedEx does its business while ensuring information integrity. Furthermore, if one could develop the system whereby information does not have human interference."*

Essentially, the thrust of the aspiration expressed above lies in the desire to reduce manual execution of some processes to reduce human error, improve efficiency, and provide visibility. The need to engender visibility in a multi-tier supply chain is addressed in Jolayemi et al, (2009), who noted that supply chains are actually now a complex multi-tier supplier network. These complex networks have to be well and efficiently monitored and managed in order to maximize the relationship value and minimize costs and risks across the multiple supply chains. This creates a dire need for the developments of SRM methodologies and models for engendering the visibility of suppliers and for integrating and synchronizing strategies and operations in multi-tier supplier systems.

SRM practitioners are expressing their preference (see comments above) for such system to be able to operate with fewer human interactions. For example, in the first phase of their project, Jolayemi et al, (2009) developed a framework – called 'Dig-Down-Shovel-Up' (DDSUP) approach to engender the visibility of lower-tier suppliers. In the second phase of their research project, Jolayemi et al, (2010) developed a prototype Decision Support System (DSS) to execute the DDSUP framework. The system can make information of the nth-tier supplier visible to the OEM with few clicks of the mouse. The system paves the way for the development of a "self-service model where all data is managed and driven to the same place"*.* Details of the prototype DSS, which has been made available to the Boeing Corporation, cannot be provided here for proprietary reasons.

Vendor evaluation, selection and stratification in SRM are labor-intensive endeavors prone to a lot of subjectivity and human error. Even when dealing with first-tier suppliers only, the task of collecting supplier information through supplier intelligence gathering is laden with errors due to heavy human interactions. Extended over several lower-tier suppliers, these human interactions and the resulting errors can be multiplied several times over. Jolayemi et al (2010) has completed a DSS using Analytical Hierarchy Process (AHP) to compute vendor attribute weights down to the n^{th}-tier suppliers, and synthesize these weights to get global priority weights that could allow first-tier vendor selection when their lower-tier supplier attributes are imbedded in the supplier-selection decision process. It is still a challenge, however, to automate the whole supplier selection process.

Managing effort or outsourcing on a consortium basis where one company manages supplier relationships (SR) of several (say 50) suppliers for an OEM

> What the Companies Say (e.g. Company E, Company F)
>
> *"Some companies are going to get smart and start doing a managing effort or outsourcing effort on a consortium basis where one company will manage, let us say, 50 different companies."*

What the comments above address is similar to what 4PLs do. Companies are gradually realizing that it has become increasingly important in the globalised economy to focus not on just core but also non-core activities such as management of long-distance supply chains in order to remain competitive (Win, 2008). In addition, they need services similar to those provided by 4PL's to build closer relationships amongst the participants in the supply chain, support cost cutting initiatives, develop the flexibility to deal with supply and demand uncertainties and ultimately to have a positive impact on the bottom-line (Frost and Sullivan, 2005). A 4PL, for example, is expected to provide the competencies relating to knowledge availability, information technology, and skills in forming and sustaining successful supply chain relationships. There is a current trend toward the involvement of 4PL providers to help manage a number of third-party logistics (3PLs) that may be involved with a company's operations. In another, strategic role, the 4PL serves as the integrator that brings together the needs of the client and the resources available through the 3PL providers, the IT providers, and the elements of business process management (Coyle et al., 2003). Similar services are needed in SRM.

Establishing long-term relationships (collaboration) with suppliers

The issue of collaboration with strategic partners is a current challenge, because few companies practice it. For this same reason, the practitioners would like to see its upward trend in future SRM practice.

Recent research studies have shown that collaboration offers promise for improved supply chain performance in several core areas, including increased sales, improved forecasts, more accurate and timely information, reduced costs, reduced inventory, and improved customer service (Daugherty et al., 1999; Waller et al., 1999; Barratt and Oliveira, 2001; Angulo et al., 2004 and Olorunniwo and Li, (2010).

Many barriers to collaboration arise from the nature of inter-firm collaboration; others are deeply embedded in corporate cultures (Parker and Anderson 2002). Among the most prevalent barriers are inadequate information sharing, turf conflicts, and inconsistent metrics (Barratt 2004; Moberg et al. 2003; Tyndall et al. 1998). To understand this barrier completely, one needs to understand stages in collaboration. In a work by Whipple and Russell (2007), three types of collaborative relationships were identified, namely: Type I, Type II, and Type III. In the Type I relationship, there is collaborative transaction management characterized by high-volume data exchange (e.g. use of EDI for VMI and scorecard collaborative initiatives) and task alignment centered on operational tasks. This is what Wiengarten et al (2010) refers to as information adequacy, accuracy, and timeliness - part of the dimensions of their 'information quality'. Type I relationships focus on transaction management with emphasis on IT tools, building data integrity, and standardizing the information that is exchanged. Type II refers to collaborative event management characterized by joint planning and decision-making activities such as in new product introductions/new store openings, new business plans, and sales promotions where there are more interpersonal interactions across collaborating firms. Type II activities involve initial collaborative planning, forecasting and replenishment (CPFR) activities and event collaboration, requiring non-transactional data. Type III – collaborative process management involves joint problem solving, long-term process planning, and more fully integrated supply chain processes such as manufacturing scheduling, truckload utilization, warehouse management, order forecasts/replenishment Here, collaborative process management requires "building trust, setting joint business goals, and designing inter-enterprise processes to meet those goals"(Whipple and Russell, 2007).

The greatest challenge lies in the implementation of Types II and/or III. This challenge, recognized by most of the companies we interviewed, has been confirmed by previous research. For example, Sandberg (2007) observed that the use of joint processes in collaboration partnerships is very low, with only 24% of the respondents in his survey admitting having jointly planned processes. Thus, the practitioners recognize that there is a need for improvement in these types of collaborations in the future.

Moving from the role of procurement managers to more of 'Supplier Business Managers'

> What the Companies Say (e.g. Company B)
>
> *""....as supply chain gets more complex we are going to get more people who have transcended the role of procurement managers, supply chain managers to more of the Supplier Business Managers. We want people who understand how these things (SRM) impact the business."*

Management consultancy has traditionally been about building strong relationships in the boardroom, with engagements being awarded based on the quality of solution and its potential benefits. Consultants have not always welcomed involvement of traditional procurement functions and their focus on detailed work specifications and costing. Traditionally, line managers engaged with consultants and then contacted procurement to follow up with the necessary paperwork. This situation is changing (and needs to change), with procurement needing now to be staffed by people experienced in relationship management that have an intimate understanding of the supplier market and the needs of their internal business clients. Today, companies are changing the role of procurement, from a process-driven function to an advisory and relationship-driven role (Newing, 2010). Such expanded role will (and should) be the way in future SRM practice.

Eliminate middle vendors – going direct to the source

> What the Companies Say (e.g. Company C)
>
> *"Eliminating the middle vendors, just have to go direct to the source. Company C is planning to purchase from China supplier directly. More and more companies will do bulk buying to reduce cost."*

Eliminating intermediaries (going directly to the supplier) is perceived to help in reducing cost. It also allows customer to monitor quality directly and possibly reduce lead-time. While these advantages may be attractive, some researchers have warned that intermediaries play a vital role in the supply chain. The reality, predicted way back, proscribes some caution in this regard. For example, Phil Anderson and Erin Anderson (2002) warned as follows:

> "At first, observers thought…. in the ruthlessly efficient world, there would be no room for middlemen. Distributors, merchants, brokers and agents, who used to get credit for sales, would no longer be paid. Channels would be straightforward, the producer mastering the details of every transaction, the identity of every customer. However, the opposite is occurring. The

> downstream part of the supply chain is becoming less straightforward, more fragmented and often longer. The conventional view of intermediaries overlooks why they exist; they solve customers' problems and, thereby, producers' problems. Their position on the high ground between both groups enables them to create value and charge for it. Although the Internet alters what the intermediary can do from the lookout post, it doesn't obliterate the inherent advantage of the position."

Wal-Mart, for example, is going directly to some farmers for their fresh produce. A major chocolate company is working directly with cocoa growers in Africa and South America, and is getting the fruits directly from them. Woods for flooring can be bought directly from the producers without going through the intermediaries. These are just a few examples of efforts to cut off the intermediaries. Beyond cost reduction objectives, other factors such as quality, risk reduction, and sustainability issues also play a role. The future will see more and more of such practice.

CONCLUSION

The future of SRM practice will be impacted by the challenges currently faced, future trends and the growing complexity of the supply chains, especially as they become increasingly global. These challenges threaten successful full-scale implementation of SRM. If the desired future trends materialize, SRM practices will be much better off. For example, sourcing efforts will be less labor intensive (prone to less human error) with the development of a "self-service model where all data is managed and driven to the same place". Holding suppliers to agreed KPIs would enable the supplier to link its own internal performance measures with the strategic objectives of the customer. Collaboration with suppliers would result in process management efforts that involve joint problem solving, long-term process planning, and more fully integrated supply chain processes.

The trends discussed above are interrelated. For example, the challenge posed by the need to hold suppliers (and their suppliers) accountable on key metrics agreed on is influenced by the depth and degree of collaborative relationships between them. Establishing and monitoring key KPIs are easier in a situation where both partners collaborate in process management with joint problem solving, long-term process planning, and more fully integrated supply chain processes. For the same reasons, development of self-service model – data managed/driven from same 'location' with standardization of supply chain systems and the capability to make the selection process robust to eliminate risk is easier in a collaborative relationship environment. Notice though that reducing the 'middle vendors – going directly to the source' may seem at first counter to the concept indicated in 'managing effort or outsourcing on a consortium basis where one company manages SR of several (say 50) suppliers for an OEM'. However, the 4PL-like company that operates a consortium might be the one that goes directly to the source, and acts to insulate the OEM from the need for several one-on-one relationships with each vendor.

The trends and prospects listed above are not totally exhaustive either. For example, issues regarding sustainability in supply chains and how these affects SRM are very important; these are not covered in this paper. Also important, but not covered here, are issues of ethical buying (e.g. eliminating child labor) and political instability. The global economy is complex, so are the current global supply chains. We expect no less complexity in the SRM practices as well.

REFERENCES

Anderson, P. and Anderson, E. (2002)," The New E-Commerce Intermediaries", *Sloan Management Review*, Summer, pp. 53-62

Angulo, A., Nachtmann, H. and Waller, M. (2004), "Supply chain information sharing in a vendor managed partnership", *Journal of Business Logistics*, Vol. 25 No. 1, pp. 101-20

Barratt, M. and Oliveira, A. (2001), "Exploring the experiences of collaborative planning initiatives", *International Journal of Physical Distribution & Logistics Management*, Vol. 31 No. 4, pp. 266-89

Barratt, M (2004), "Unveiling Enablers and Inhibitors in Collaborative Planning", *The International Journal of Logistics Management*, Vol. 15, No. 1, pp. 73-91

Carter, C. R. and Jennings, M.M (2000), "Purchasing's Contribution to the Socially Responsible Management of the Supply Chain", *Centre for Advanced Purchasing Studies, Arizona State University, Arizona.*

Carter, S (2010); "Supplier Management- What is a Supplier Relationship Management–Program?" *http:ezinearticles.com, Accessed 9_19_2010.*

Coyle, J.J., Bardi, E.J. and Langley, C.J. Jr (2003), The Management of Business Logistics: A Supply Chain Perspective, 7th ed., *South-Western Publishing*, Mason, OH.

Daugherty, P.J., Myers, M.B. and Autry, C.W. (1999), "Automatic replenishment programs: an empirical examination", *Journal of Business Logistics*, Vol. 20 No. 2, pp. 63-82

Doolen, T., Traxler M., McBride K. (2006), "Using Scorecards for Supplier Performance Improvement: Case Application in a Lean Manufacturing Organization", *Engineering Management Journal*; 18, 2; pp 26

Fawcett, S.E., Magnan,G.M. and McCarter, M.W. (2008), " A Three-Stage Implementation Model for Supply Chain Collaboration", *Journal of Business Logistics*, Vol. 29, No 1, pg 93

Frost and Sullivan (2005), "Next Generation Supply Chain Strategies in Europe: End-user Attitudes & Perceptions Toward Fourth Party Logistics Engagements & Opportunity Assessment for a Business Case", available at: www.researchandmarkets.com

Jolayemi, J.K., Fan, C., Olorunniwo, F.O., and Li, X. (2009), "Supplier Relationship Management in Multiple Supply Chains - Phase I", *Unpublished First Year Research Report from Boeing Corporation Research Grant,* Tennessee State University, Nashville, TN.

Jolayemi, J.K., Huang, K., Shetty, M, Fan, C. and Olorunniwo, F.O. (2010), "Supplier Relationship Management in Multiple Supply Chains - Phase II", *Unpublished Second Year Research Report from Boeing Corporation Research Grant*, Tennessee State University, Nashville, TN

Moberg, C B., Thomas W. Speh, and Thomas L. Freese (2003), "SCM: Making the Vision a Reality", *Supply Chain Management Review*, Vol. 7, No. 5, pp. 34-40

Newing, R. (2010), "Using consultants: BP highlights changing role of procurement function in relationships with key suppliers", *Financial Times,*2 November 15.

Olorunniwo, F. O. and Li, X. (2010), "Information sharing and collaboration practices in reverse logistics"; *Supply Chain Management-An International Journal*, Vol. 15, No. 6, pp. 454-462.

Parker, Geoffrey G., Edward G. Anderson, Jr. (2002), "From Buyer to Integrator: The Transformation of the Supply-Chain Manager in the Vertically Disintegrating Firm", *Production and Operations Management*, Vol. 11, No. 1, pp. 75-92

Rizza, M.N. (2006), "Supplier Performance Management Can Make a Difference", *Supply Chain Management Review*, October

Sandberg, E. (2007), "Logistics collaboration in supply chains: practice vs. theory", *International Journal of Logistics Management, Vol. 18 No. 2, pp. 274-293.*

Waller, M.A., Johnson, E.M. and Davis, T. (1999), "Vendor-managed inventory in the retail supply chain", *Journal of Business Logistics*, Vol. 20 No. 1, pp. 183-203

Wiengarten, F., Humphreys, P., Cao, G., Fynes, B. and McKittrick, A. (2010), " Collaborative supply chain practices and performance: exploring the role of information quality"; *Supply Chain Management-An International Journal*, Vol. 15, No. 6, pp. 463-473.

Whipple, J. M. and Russell, D. (2007), "Building supply chain collaboration: a typology of collaborative approaches", *The International Journal of Logistics Management*, Vol. 18 No. 2, pp.174-196.

Win, Alan (2008), "The value a 4PL provider can contribute to an organization", *International Journal of Physical Distribution & Logistics Management, 38*(9), 674-684

ACKNOWLEDGEMENTS: This research on "Supplier Relationship Management in Multi-tier Supply Chains" was supported by a research grant from The Boeing Corporation (2009). We also thank the Graduate Assistants- Gift Bondwe and Sai Priya Sista- for their assistance in collecting some of the data information that helped in this research.

THE DIAGNOSIS OF COMPLEXITY WITHIN A MEDICAL CONSUMABLES MANUFACTURING COMPANY

Sakshi Dhingra[1], Andrew Potter[1], Richard Barton[2]
[1]Cardiff Business School, Cardiff University
[2]Newport Business School, University of Wales Newport

INTRODUCTION

Most complexity within organizations is unintended. The organizational structure, management system and behaviour, products and processes, economic conditions and mergers/acquisitions are varied sources of complexity. Managers must be aware of both internal and external complexity sources but could themselves be a complexity source through the way they make decisions and manage people and processes. While there is a broad spectrum of papers published on the concept of complexity, there is a lack of clarity in the definition of the term and how the frameworks can be applied in an industrial context. The aim of this paper is to address this gap, through the synthesis and application of existing frameworks into a real-world application, thereby demonstrating how organisations may address complexity.

The framework behind this can be found in Figure 1. Every organization possesses a 'Basic Complexity' arising from its strategic objectives, market positioning and resources. The use of complexity reduction levers reduces basic complexity to the organisation's 'Actual Complexity'. When management levers are adopted to further control the impact of complexity rather than reducing it, the resulting complexity level observed through the organization's performance is called 'Perceived Complexity' (Perona and Miragliotta, 2004). There then exists a feedback loop where the causes and consequences of complexity generate further management actions, which can also be influenced by the system characteristics. This may also include structural changes which affect the underlying basic complexity in the system.

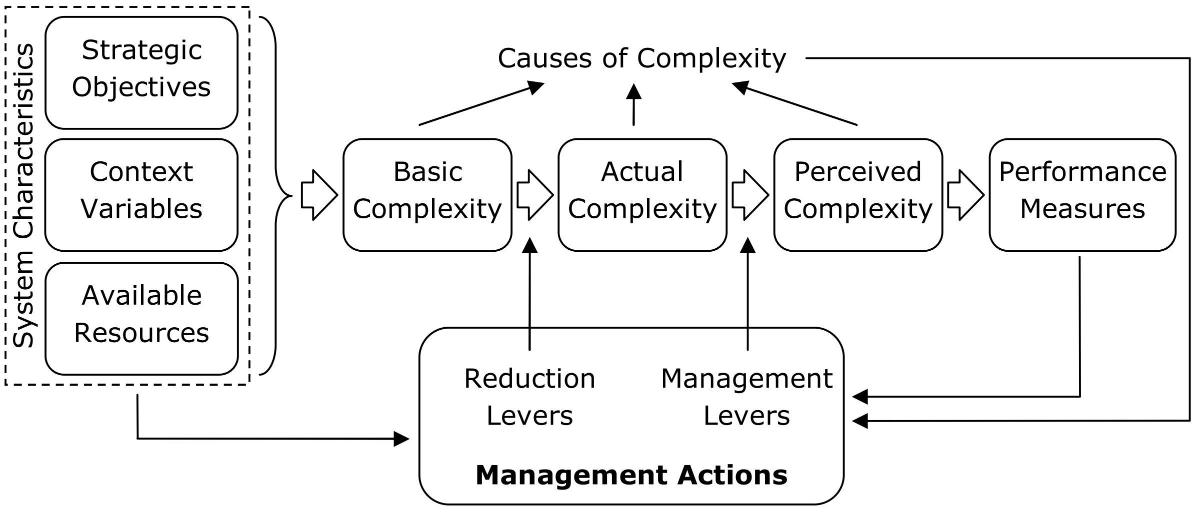


Figure 1: Framework for analysing complexity (adapted from Perona & Miragliotta, 2004)

The case company is a manufacturer of medical consumables, and a division of a global corporation from the pharmaceutical sector. The products are used in the diagnosis of diseases such as HIV and Hepatitis. Their supply chain network is geographically vast due to the nature of the business, the raw materials used and the product requirements. The scope of the study is a single manufacturing plant in the UK and its distribution to distribution centres (DCs) in Europe and the USA. Unlike some industrial sectors, the manufacture of diagnostic kits is highly controlled by regulations and standardizations (Fritzler et al, 2003).

The paper proceeds as follows. Firstly, the literature around complexity is reviewed, based on the framework for analysis in Figure 1. The method is presented, followed by the analysis. This focuses on the causes of uncertainty, how it can be measured and finally potential management interventions that could be taken. This leads to a proposed course of action for the case company, followed by overall conclusions.

COMPLEXITY IN MANUFACTURING SYSTEMS

A complex system is that made up of a number of different parts interacting in a non-simple way, such that it becomes difficult to predict the system's behaviour without detailed analysis or computation (Bozarth et al 2009; Deshmukh et al 1998). Complexity is often confused with complicatedness and uncertainty, whereas they are actually the two main factors contributing to it. Indeed, Waldrop (1992) comments that complexity is a dynamism that makes systems 'qualitatively different from static matter like computer-chips or snowflakes which are only complicated'.

An early and well known framework in this area is the supply chain complexity triangle put forward by Wilding (1998). This emphasised uncertainty and the 'far-from-equilibrium' behaviour within supply chains that causes complexity. Three independent yet interactive factors were specifically identified – deterministic chaos (relating to the structure of operations), demand amplification (changing the dynamic behaviour of the system) and parallel interactions (where supply chains interact with each other).

Later frameworks have been developed to identify where complexity occurs and to further distinguish between uncertainty and complicatedness. Vachon and Klassen (2002) developed a 2-by-2 matrix for supply-chain complexity, describing the technological, managerial and product variables and studied their effect on delivery performance. Technology and information processing are introduced as the 2 dimensions to complexity. The former relates to product/process structure and the management system infrastructure. Uncertainty and complicatedness were seen to cause complexity in relation to information processing. This two way relationship between technology and information is also reflected in the frameworks of Milgate (2001) and Ashkenas (2010).

An alternative framework put forward by Perona and Miragliotta (2004) identifies five key dimensions for uncertainty, reflecting a process based perspective of a manufacturing system. Interestingly, while providing more detail than Vachon and Klassen (2002) on the process and product structure, they do not explicitly include the management system variable apparent in other frameworks. On the basis of this, Table 1 has been developed to categorise the causes of uncertainty, populated with examples from all of the above literature.

	New Product Development	Sales Processes	Inbound/ Outbound Logistics	Production Process	Production Engineering	Managerial Decision Making
Complicatedness	• Structure • Modifications in design • Co-design and co-ordination • Patent	• Product range and customization • Absence of suitable pricing mechanisms • Lacking information visibility	• Production capability of suppliers • Stock holding costs • Delivery frequencies • Parallel interactions • Outsourcing • Number of echelons • Geographical span of suppliers & customers	• Production capabilities • Demand forecast upgrading • Safety stock levels • Poor quality delivery • Throughput time variations and setup times • Stock levels inaccuracy • Fraud, theft and bending rules • ERP system logic • Production planning	• Production resources • Plant location • Limited storage space	• Strategies and objectives • Manpower • Capacity Allocation • Product information • Process information • Cost • Scheduling/ planning changes • Demand volatility • Delayed supplier delivery • Price fluctuations
Uncertainty	• Lifecycle length • Government and safety regulations & restrictions	• Demand forecasting • Delivery constraints • Priority orders • Product ordering • Record systems • Last minute cancellations	• Operational problems (loading/ unloading) • Congestion • Supplier backlog	• Product variety • Production skills/know-how • Number of sub-processes • Number of components • Level of interaction between different components	• Deterministic chaos - Control systems • Technology	• Lack of Information Processing • Poorly designed systems used

Table 1: Causes of complexity (adapted from Vachon and Klassen, 2002, Perona and Miragliotta, 2004)

The above frameworks conclude that complexity has a high negative impact on the overall supply chain efficiency, performance, reliability and cost. According to Bhatnagar and Sohal (2005), organisational performance is affected by various factors from decision of plant location to the production processes and the uncertainty within the supply chain being the most important. Elements of complicatedness, like number of suppliers and product variety increases the involvement in various activities and raises costs (Bozarth et al, 2009). Uncertainty can, for example, generate complicated and long procedure changes. Overall, it is considered that complexity can have a negative effect on metrics such as lead time, quality, inventory, schedule attainment, delivery delays and customer satisfaction (Bhatnagar and Sohal, 2005).

Reducing or managing complexity through a strategy focusing on simpler, streamlined processes, along with specialization and flexibility enhances organizational performance (Vachon and Klassen, 2002). Perona and Miragliotta (2004) identify reduction levers and management levers as key variables that affect the change from basic complexity to actual complexity. Hoole (2005) also identifies a number of 'levers' through which complexity can be reduced. Combining these, the framework in Figure 2 can be developed as a way of reducing complexity in manufacturing systems.

Figure 2: Complexity control levers (adapted from Perona and Miragliotta, 2004, and Hoole, 2005)

METHOD

The research adopted a qualitative approach to data collection. Four semi-structured interviews with appropriate managers were conducted allowing interviewees to express their views on the various issues within the case company. The questions were e-mailed in advance to interviewees. This allowed them to prepare in advance so that they felt comfortable during the interview and could provide any documented information to support their answers. They were asked to express their definitions of complexity and the causes they felt were responsible for it. The 5-why approach of analysing the root causes was used. The discussion went onto the various performance measures and the problem resolution methods adopted by the company along with the future challenges that the case company and the medical diagnostics industry could face. The interviews were supported by archival evidence from other sources, such as process maps. This enabled triangulation to occur, to improve the reliability of the research findings.

The information gathered from interviews was analysed and structured in diagrammatic forms. Using the structure from Table 1, a series of fishbone diagrams were produced to categorise the causes of complexity. The measures used to evaluate the impact of complexity were tabulated, along with the complexity sources and causes. Appropriate performance measures which were currently unemployed were recommended for the case company, along with management actions to change the level of complexity.

CAUSES OF COMPLEXITY

Complicatedness

Figure 3 presents the fishbone diagram relating to complicatedness as a cause of complexity within the case company operations. Most interviewees emphasized that complicatedness was 'product driven' due to the nature and the variety of assays, each having a variety of raw materials and the difficulty in making different combinations. Different markets have different requirements, such as where raw materials can be sourced from. Indeed, regulation is a significant external factor. Tight product specifications are set and if not met, re-work and re-testing are required to avoid further regulatory issues. Even simple changes in production can become complicated due to regulatory requirements.

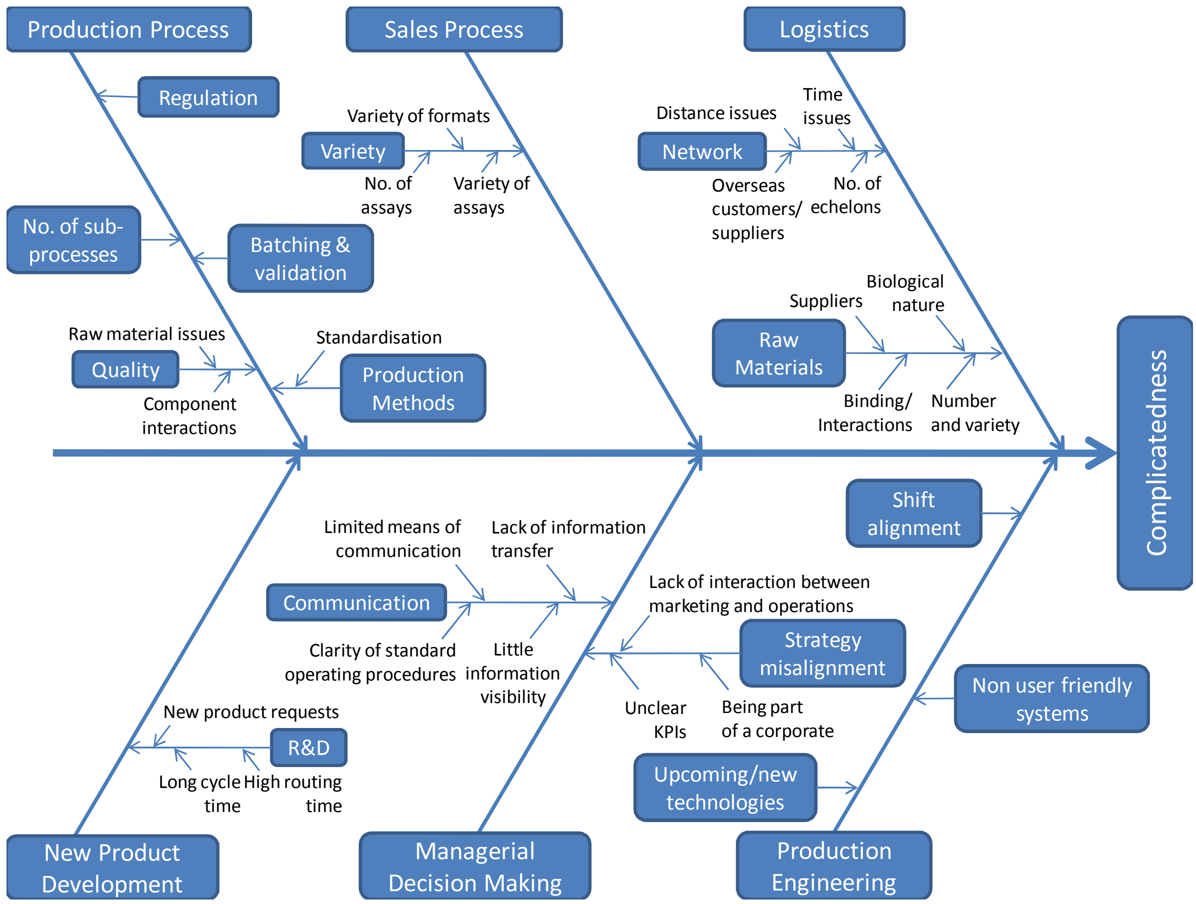


Figure 3: Causes of complicatedness in the case company

Decisions leading to a large supplier and customer base, with an increased number of echelons, have also lead to complicatedness. The DCs face such complicatedness as they either supply products to customers directly or through agencies. Being part of a big diverse corporate, the case company uses management control systems which are not suited to its operations. This further increases complicatedness as repetitiveness was observed within the systems.

The geography of the operations is also an issue. Communication with suppliers and DCs is largely by e-mail, while the marketing department is located some distance away and interacts little with production. The operations team does not get a clear vision of the marketing strategy, although the operations strategy should be aligned with this. They are the last to be informed of customer orders made, due to transparency issues.

Uncertainty

According to interviewees, the largest source of uncertainty was the raw material suppliers. The case company has a vast supplier base especially for biological raw materials. Many antibodies, proteins and serums come from the US and late deliveries cause disruptions in production. Due to the complicated nature of the materials and regulatory requirements, multiple sourcing would increase complexity. Thus most raw materials (antibodies/antigens) are single sourced although relationships with alternative suppliers are maintained.

Demand forecasting and fluctuations as a result of limited control over customers, i.e. the distribution centres, causes chaos. This creates issues like over- or out of stock and increases lead times. Production schedules are unstable and change on weekly basis. Raw material misses and, more importantly, technical issues with assays and quality cause schedule misses. Fluctuations in raw material prices also contribute to demand amplification.

Scrap is produced due to quality test failures and over-ordering resulting from incorrect forecasting and batch sizes. Small percentages of scrap are also produced when testing new combinations of raw materials that are requested by customers. Much of the scrap produced is linked to the complicated nature of products and the interactions between the components. Rework is also an issue when test failures occur at the product release stage. Troubleshooting the problem consumes a long time, and may require a new batch to be produced. Thus, the entire process of manufacturing and verification has to be repeated.

MEASURES OF COMPLEXITY

A variety of common measures were identified from various literature sources. First these measures were listed for the different complexity causes and sources, while recognising that they may actually be influenced by more than one cause. This list was compared against those currently used in the case company, as presented in Table 3.

CONTROLLING COMPLEXITY

Most of the lean production techniques focus on complexity reduction whereas flexibility attaining techniques focus on managing complexity which is required by top management to be competitive. Thus complexity could be controlled through reduction and management levers. Drawing on examples from elsewhere, some potential options for the case company were identified:

- Flexibility - Reducing lead and cycle times increases flexibility as it is highly customer driven. It is directly related to the degree of standardization and commonality (New, 1996). At Yokogawa Electric's Kofu plant in Japan, lead times were more than a month but, by introducing flexibility in production and distribution, it has been significantly reduced to 48 hours (New, 1996). It also increased its capacity and labour to meet demands quickly. The case company is also bringing changes by introducing auto-sensing and back-end automation to increase efficiency.

Source of Complicatedness	Measures from literature	Measured at case company	Source of Uncertainty	Measures from literature	Measured at case company
Management	• MRP System	N	Delays	• Delivery Performance	Y

Infrastructure	Performance • Competitive benchmarking • Profitability • Systemized logistics planning • Concreteness of future plans	N Y N Y		• Schedule Adherence • Fill rate • Inefficient control/info systems • Product Quality • Supplier issues • Customer complaints • D:P	Y Y Y Y Y Y N
Product	• Quality • Rework • Commonality Reports	Y Y N	Chaos	• Safety Lead Times • Short Interval Scheduling System	Y N
Regulations	• Code of Ethics • Performance statistics • Public performance evaluation • Testing & Validation	N Y N Y	Amplification	• Capacity Utilization • Forecast errors (%) • Safety Stock • Lead times	N Y Y Y
Process	• Schedule adherence • SPC • Cost • D:P • Influence on associated companies	Y N Y N N	WIP	• Rework • Rescheduling • Lead times • Distance of material moved	Y Y Y N
Communication	• Cross functional Interactions • HR productivity • SMART • Influence on associated companies • Intellectual Capital	Y Y N N N	Scrap	• %Scrap/ Defects • % Scrap Value reduction • Customer complaints • Quality (Non-conformances) • Cost & Profitability	Y Y Y Y Y
Coordination	• SIOP • Work centres	Y Y	Parallel Interactions	• Yield • SMART	Y N

Table 3: Performance measures for complexity

- Creating a streamlined, transparent and less complex product portfolio – This is a strategy adopted by Siemens (Ashkenas, 2010). It involves using structured simplification approaches like Six Sigma but it is essential that the same principles are applied in every department.
- Lean manufacturing – The case company is aiming to reduce lead times, eliminate packing inspection and reduce rework activities in operations by targeting the reduction of technical problems.
- Pricing models – This encourages shippers and suppliers to provide accurate and on-time information about supply deliveries else they should be charged. Such models encourage better transparency and coordination within the supply chain and thus prevent delays and delivery issues. Currently, these are not used effectively within the case company.
- Supplier relationships – Communication and good relationships with suppliers are essential. Linn Products, an entertainment products company, improved their performance by providing advise to suppliers, while Nissan organized a 'Supplier development team' to monitor and improve their performance (New, 1996).
- Management systems - DMAIC is a process used by management in the case company to find root causes of problems by Defining the issue, Measuring failures and Analyzing its nature through experimentation and then employ Improvement and Control measures. Sales Inventory and Operations Planning (SIOP) monitors and helps define future requirements.

Comparing the potential options for the case company against tools and techniques they currently employ, it is clear that their lean manufacturing initiatives should be effective in addressing the complicatedness of their complexity. However, the adoption of approaches for managing the uncertainty aspects is lower and therefore exposes the company to risks in this area.

CONCLUSIONS

This paper has examined the issue of complexity within manufacturing systems, through the synthesis and application of established frameworks into a case application from the medical consumables sector. The research has highlighted that there are two main aspects to complexity – complicatedness and uncertainty – and it is important to focus on both of these in looking to reduce its impact. It is also important to consider not only the physical aspects of the supply chain, but also the management system which governs operations. This systems view ensures that all aspects of complexity are evaluated.

The paper has also demonstrated how, having identified causes of complexity, it is possible to evaluate the links to performance measurement. This is important in allowing management to understand where complexity may be having an impact and, more importantly, to provide a guide as to the types of levers that may be used to reduce complexity. Some potential levers are also discussed, and their current application within the case company highlighted. This gives rise to future opportunities for change to improve resilience against complexity.

REFERENCES

Ashkenas, R (2010) "Simply Effective: How to cut through complexity in your organization and get things done", Harvard Business Press: Boston.

Bhatnagar, R and Sohal, AS (2005), "Supply chain competitiveness: Measuring the impact of location factors, uncertainty and manufacturing practices", Technovation, 25, 443-456.

Bozarth, C, Warsing, D, Flynn, B and Flynn, E. (2009) "The Impact of Supply Chain Complexity on Manufacturing Plant Performance", Journal of Operations Management, 27(1), 78-93.

Deshmukh, AV, Talavage JJ and Barash, MM (1998) "Complexity in manufacturing systems part 1 : Analysis of static complexity" IEEE Transactions. 30, 645-655.

Fritzler, MJ, Wiik, A, Fritzler, ML and Barr, SG (2003) "The use and misuse of commercial kits used to detect autoantibodies", Arthritis Research and Therapy, 5(4), 192-201.

Hoole, R (2005) "Five ways to simplify your supply chain", Supply Chain Management: An International Journal, 10(1), 3-6.

Milgate, M (2001) "Supply Chain Complexity and Delivery Performance: An International Exploratory study", Supply Chain Management: An International Journal, 6(3) 106-118.

New, SJ (1996) "A framework for analysing supply chain improvement", International Journal of Operations and Production Management, 16(4), 19-34.

Perona, M and Miragliotta G. (2004) "Complexity Management and Supply Chain Performance assessment: A field study and a conceptual framework", International Journal of Production Economics, 90, 103-115.

Vachon, S and Klassen, RD (2002) "An exploratory investigation on the effects of supply chain complexity on delivery performance", IEEE Transactions of Engineering Management, 49(3), 218-230.

Waldrop, M. (1992) "Complexity: The emerging science at the edge of order and chaos", Simon & Schuster, New York.

Wilding, R (1998) "The Supply Chain Complexity Triangle", International Journal of Physical Distribution and Logistics Management, 28(8), 599-616.

SUPPLY CHAIN RISK MANAGEMENT: AN ANALYSIS OF PRESENT AND FUTURE SCOPE

Abhijeet Ghadge[1], Samir Dani[1] and Roy Kalawsky[2]
[1]School of Business and Economics, Loughborough University, Loughborough, UK
[2]Research School of Systems Engineering, Loughborough University, UK

ABSTRACT
Supply chain risk management has increasingly attracted researchers as well as practitioners in recent years. Literature reviews on this topic have provided a good platform for beginners in the field of SCRM. However this paper assumes that the SCRM researcher will benefit from a systematic literature review in which the SCRM field is studied holistically based on different typologies. The study considers papers published over a period of ten years and depicts the prominent strategic changes in SCRM research analysed from numerous perspectives. The outcome of this systematic literature review has provided insights into the present and future scope of SCRM field. This research expects to provide researchers and managers a quick but insightful understanding of the length and breadth of the SCRM field. The identified research insights, gaps and future directions will encourage new research techniques to manage risks in the globalized supply chain environment.

INTRODUCTION
Information explosion from multiple data sources in today's e-world demands more explicit and justifiable knowledge about the research area. Supply Chain Risk Management (SCRM) is one such research area which has increasingly attracted the interest of both, academicians and practitioners. SCRM is believed to be in an emerging and nascent stage by researchers (Sodhi et.al, 2011). It clearly has undefined boundaries in its scope of research. Literature review on SCRM is carried out in past by Juttner et. al. (2003); Vanany et. al. (2009) and Rao and Goldsby (2009). These literature reviews provide a good platform for beginners as well practitioners in making sense of the ongoing research and identifying the state-of-art within the field. However, the recent reviews have been focussed around certain journals or around identifying risk management practices. Narrative literature reviews are believed to lack thoroughness and rigour (Tranfield. et.al, 2003). Evidence based reviews are considered to be thorough and transparent as they provide insights into field by literature being analyzed through a number of perspectives. The Systematic review approach provides an evidence base for literature survey (Tranfield et al., 2003; Rousseau et al., 2008; Denyer and Tranfield, 2009). In this paper, a Systematic Literature Review (SLR) of the SCRM field is carried out following a structured process. SLR which is prominently used in the field of medical science, has expanded its roots in management. The SLR process followed in this paper is adapted from the work done by Tranfield et. al. (2003) for developing evidence-informed management knowledge.

The following section will briefly cover the background and current advances in SCRM for a quick overview of the research field. Later, research methodology followed for systematic literature review is presented. The SLR approach has provided critical insights into SCRM research and is presented in the analysis and findings section. Identified gaps in existing work are used in defining present and future scope of SCRM is presented in concluding section.

SUPPLY CHAIN RISK MANAGEMENT
Managing risks in the modern environment is becoming increasingly challenging (Christopher and Lee, 2004). This is primarily because of uncertainties in supply and demand, globalization of markets and short product life cycles. Risk can be defined as a potential for unwanted negative consequences to arise from an event or activity (Rowe, 1980). The global business environment today is influenced by financial instability, increased outsourcing, mergers, new technologies, e-business, shorter time-to-market,

thus forcing organizations to adopt new ways of doing business (Stefanovic et. al., 2009). Supply chains are growing more global and complex, they are driven by customer expectations for reduced costs and increased flexibility. Today's leaner, just-in-time globalized supply chains are more vulnerable than ever before to operational, natural and man-made disruptions. Vulnerability is defined as an exposure to serious disturbance arising from risks within the supply chain as well as risks external to the supply chain (Christopher and Peck, 2004).

Supply chain risk can be broadly defined as an exposure to serious disturbance arising within a supply chain affecting its ability to effectively serve the end customer market. The SCRM approach generates added value to industry by providing better understanding of supply chain risks, greater influence and control over suppliers, increased quality and reliability of products with increased efficiency and reduced operational costs. Supply chain risk sources are any variables which are unpredictable and can disrupt the complete network. Risk management in supply chain is driven by systemic interrelationships focusing at identification and reduction of risks not only at organization level but focusing on the entire supply chain. Risk management is becoming integral part of a holistic SCM design (Christopher and Lee, 2004). There is diverse classification of supply chain risks in literature. Risk itself is termed in many ways such as disruption, vulnerability, uncertainty and disaster in field of Supply chain risk management.

RESEARCH METHODOLOGY

Systematic reviews differ from traditional narrative reviews by adopting a replicable, scientific and transparent process (Tranfield. et.al, 2003). We have adapted the SLR process followed by Tranfield et. al. (2003) for developing evidence-informed management knowledge in this area. The research design followed for systematic literature review and for identifying the scope of SCRM research is followed in four phases as shown in figure 1. Although the SLR methodology is not widely used within the management field, it is found to have reasonable acceptance as a desired methodology in literature review for researchers (Badger et. al, 2000).

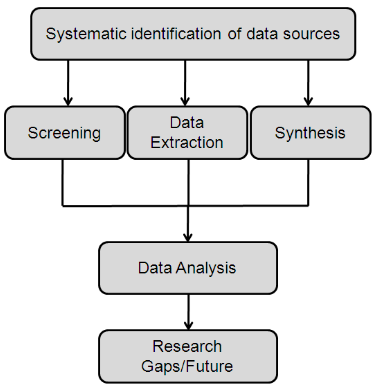


Figure 1: Research Design approach (adapted from Tranfield et. al., 2003)

Systematic identification of data sources

In the first phase, a review panel of experts is formed who can share their valuable opinions in areas of research methodology and research theory. The preliminary stage of the SLR process is mainly an iterative process of definition, clarification, and refinement (Clarke and Oxman, 2001). While managing SLR, it is necessary to assess the relevance of the literature and to delimit it by considering cross-disciplinary perspectives (Transfield. et. al., 2003). The SLR review plan usually contains a conceptual discussion of the research problem rather than a defined research question in other technical fields.

Screening, Data Extraction and Synthesis

Comprehensive and unbiased search is one of the fundamental differences between a traditional narrative review and a systematic review (Lemmner et.al., 1999). The systematic review methodology is designed to reduce any unintended bias, which may occur in the use of other review methodologies (Bimrose. et. al, 2005). SLR screening is decided based on search strings or keywords considered most appropriate based on discussion with experts. The output of this stage should be full listing of core contributing articles on which data analysis will be carried in objective and unbiased manner. This listing should meet all inclusion and exclusion criteria as decided in review plan. The number of sources included/excluded should be well documented with appropriate reasons. Research synthesis is term referred for family of methods used in review for analysing and summarising the findings.

Data Analysis

Systematic reviews mainly use quantitative methods. This is most rigorous process of all other processes in SLR. We rely on implicit quality rating of journal before analysing data through quantitative tools like statistical analysis and citation/co-citation analysis.

Dissemination and Reporting

Management research output could be presented in two stages. The first would be descriptive analysis providing set of classification on various attributes used in data analysis. Later, Findings of thematic analysis could be reported through aggregative and interpretative approach.

ANALYSIS AND FINDINGS

Using the above proposed research design for SLR, a panel of experts and academic researchers in field of Supply chain were sought to provide directions for literature survey. To identify research articles for conducting quality analysis we used quality rating of journals in Operations Management/Research and Management Science area. We strictly followed the journal quality rating provided in 'Journal Quality Guide' published by ABS (Association of Business Schools, UK) and referred to only journals in above mentioned areas with an average of 3 quality rating (excepting two) in last two years (2009,2010). These papers are heavily refereed and research is highly regarded (ABS Journal Guide 2010). Figure 2 shows 15 identified data sources with their ABS ranking in OM and OR/MS area. The keywords and search strings used for filtering the raw data from data sources were identified as Risk, Disruption, Vulnerability, and uncertainty. These keywords were identified based on earlier understanding of the SCRM field supported and during discussions with academicians and practitioners during the 10th International Research Seminar on Supply Chain Risk Management in 2010 organised by the International Supply Chain Risk Management Network (ISCRiM).

SR. No.	Key Subject field	List of Journals	ABS Ranking*
1	Operations Management (OM)	Journal of Operations Management (JOM)	4
2		Production and Operations Management (POM)	3
3		International Journal of Production Economics (IJPE)	3
4		International Journal of Operations and Production Management (IJOPM)	3
5		Supply Chain Management: An International Journal (SCMIJ)	3
6		International Journal of Production Research (IJPR)	3
7		Production Planning and Control (PPC)	3
8		International Journal of Logistics: Research and Applications (IJLRA)	2
9		International Journal of Logistics Management (IJLM)	2
10		International Journal of Physical Distribution and Logistics Management (IJPDLM)	2
11	Operations Research and Management Science (OR/MS)	Management Science (MS)	4
12		European Journal of Operational Research (EJOR)	3
13		Naval Research Logistics (NRL)	3
14		Omega: The International Journal of Management Science (OMEGA)	3
15		Decision Sciences (DS)	3

Table 1: Identified data sources (*ABS ranking as on 17 Nov. 2010)

In order to restrict the scope of literature survey, we decided to analyse articles published only in last one decade (from 2000 to 2010). We believed the year 2000 as an appropriate starting point even though the term 'supply chain management' was first coined by an American industry consultant in the early 1980s. After 2000, more Quantitative orientated articles were published (Tang and Nurmaya Musa, 2010). It was observed in preliminary search that, significant number of researchers started working on SCRM in early 2000. Global recession affecting supply chain in 2001-02 (Hilmola, 2005)

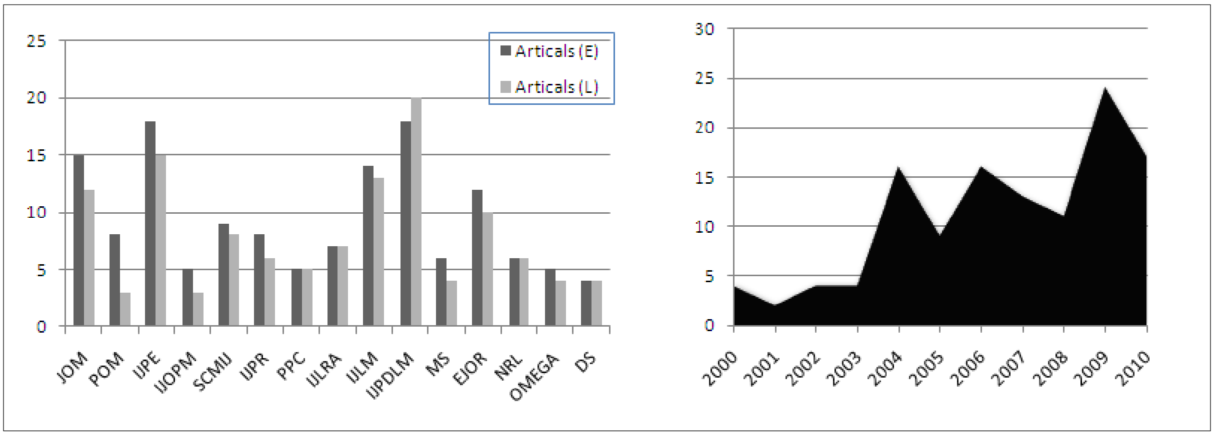


Figure 2: Journal-wise and year-wise distribution of articles

and challenges in outsourcing seem to have given a sound platform for research on risk management in supply chain in the early stage of the decade. The initial search using keywords/search strings within identified journals and filtering by year of publication from 2000 to 2010 yielded 140 articles. We further refined this search and eliminated articles discussing risk management in other interdisciplinary fields like Finance, Enterprise, Information Technology, etc. In order to improve the quality of research we finally classified 120 articles individually and independently for data extraction process. It was observed that there was a radical increase in number of articles published from year 2004 in field of SCRM (figure 2). Preliminary studies showed that the traditional focus of supply chains looking at operational risks shifted towards more strategic risks due to an increase in global outsourcing activities. 9/11 attack disrupting major supply chain in early decade also triggered interest in SCRM field (Chopra and Sodhi, 2004; Sheffi, 2005). Year 2009 represented as a most promising year in SCRM contributing most in volume. Complete financial meltdown by the middle of 2008 is expected to be one of the reasons for surge in research in subsequent year. Descriptive analysis of keywords and countries contributing to SCRM showed USA and UK contributing most to SCRM research supported with more than two third of publications. This may be due to the fact that USA, UK along with other European countries outsource the most and are vulnerable to risks. This is assumed to drive the interest of researchers from these countries. Risk and Disruption are most commonly used terms to represent exposure to serious disturbance in supply chain. Few other prominently used terms found in literature were vulnerability, uncertainty, disaster and crisis. The Risk term is mainly referred to organizational and network related disturbance whereas Disruption is commonly referred to exposure to environmental (man-made and natural) disturbances.

Data synthesis was done using various predetermined criteria's. Typology were identified as shown below:

Based on type of risk: There is diversity in classifying risks in SCRM (Ghadge.et.al, 2010), this demanded clear and distinct classification for data analysis. We followed the classification provided by Juttner et. al. (2003) based on sources of risk as Organizational

risk, Network Risk and Other risks comprising of environmental (man-made and natural disasters), political/Social and exchange rate risks.
Based on Management level: Mitigation strategies are decided based on expected level of management. It could be Operational, Tactical or Strategic depending on the nature of problem and requirement.
Based on research methodology: Qualitative and Quantitative research methodologies are classified to understand tools and techniques used in SCRM.
Based on risk management process: Based on perception of researchers in SCRM risk management process is generally classified as risk identification, assessment and mitigation and/or control.
Based on approach to SCRM: Risk mitigation approach could be either proactive or reactive. This is done to identify mitigation strategies commonly used in field of SCRM.

Typology type	All Journals	OM Journals	OR/MS Journals	Typology type	All Journals	OM Journals	OR/MS Journals
Contributing country	%	%	%	**Research approach**	%	%	%
USA	46.66	43.47	57.14	*Qualitative*	54.16	67.39	10.71
UK	15.83	20.65	0.00	*Quantitative*	36.66	23.91	78.57
International	16.66	11.95	32.14	*Mixed*	9.16	8.69	10.71
Other countries	21.66	25.00	10.71				
				Risk management process			
Publication period				*Identification*	35.00	32.39	5.89
2000-2005	32.50	35.86	78.57	*Assessment*	14.33	16.64	78.14
2006-2010	67.50	64.13	21.42	*Mitigation/Control*	5.83	4.72	13.84
				Holistic	44.16	46.47	2.85
Type of Risk							
Organizational	4.85	5.87	0.00	**Risk mitigation approach***			
Network	48.78	52.69	11.65	*Proactive*	56.33	41.60	60.71
Other	14.63	12.38	50.61	*Reactive*	23.33	13.91	18.42
Holistic	31.66	28.58	38.42	*Holistic*	20.83	44.92	21.07

***** *Only 61 articles of 120 discussed about proactive/reactive approach.*

Table 3: Statistics of articles in SCRM

Analysis based on various typologies showed interesting results. This analysis was carried with an assumption that the authors contributing to SCRM research from various countries have an inherent interest in particular research area and are faced with similar kind of risks in their own country or region. Statistical analysis showed almost half (46.66%) of the contribution alone coming from USA leaving apart major stake in collaborative work with other countries (16.66%) '*International'* is word used to indicate collaborative research among co-authors representing more than two countries (Altay and Green, 2006). UK found leading next to USA along with tangible contribution from other countries like Sweden, China, Canada, and Italy also showing keen interest in supply chain disruptions. It is surprising to see that all contributory work from UK is published only in Operations Management (OM) journals. The journals from the OM domains are more influential then OR/MS (Petersen et. al., 2011). Most of UK research work is qualitative in nature and this could be a reason for not found in OR/MS journals focusing on application of quantitative methods for decision making (Chase et al., 2006).

By dividing the decade into two halves for analysis, it showed a distinctive growth of SCRM from an undefined area to an emerging area for practitioners and researchers in supply chain management. Publications in later part of decade almost doubled compared to previous half (Table 3). This clearly shows the potential of SCRM research in current dynamic world. Identified probable reasons for this trend are already discussed. Thematic analysis of other typology provided interpretative results underlining the scope of SCRM field for future. Organizational risks comprising of Inventory risk, process/operational risk, labour risk, Product quality risk and safety risk are quite frequently discussed in literature. Network related risk sources arise from interactions between organisations within the supply chain (juttner et. al, 2003). Supply and demand risk, supplier default, outsourcing quality risk, logistics risk forming Network related risks is found to be most researched (48.78%) for its obvious reasons of being "extrinsic" in nature of risk. Recent research has shown increased attention towards environmental (man-made and natural) disruptions due to several global events in past disrupting supply chain like 9/11 terrorist attack (2001), SARS (2003), Tsunami (2004), Hurricanes (2005) and geopolitical instability (2010).

Data synthesis of research methodologies used for tackling the problems in SCRM field was broadly classified as Qualitative and Quantitative methods. During preliminary analysis it was evident that, Qualitative methods are preferred by SCRM researchers (table 3). Detailed analysis of data classified as Qualitative, Quantitative and mixed methods showed case study approach being most adopted by researchers for dealing with problems mainly at strategic management level. More than 80% of case studies are found to be focussed on network related risks. In qualitative research methods; other prominently used tools are exploratory analysis of secondary data (11.67%), Conceptual theory building for developing frameworks (10.83%) and use of Interviews/Questionnaires/Focus group study (10.00%). Conceptual frameworks mainly focused on risk identification activity whereas outcomes of case studies were developed as risk mitigation strategies for implementation in similar case environments. Interviews, Questionnaires and Focus group study are found to be commonly used for risk identification and risk assessment activities primarily at a strategic level of management. Since a literature survey provides platform for conceptual theory building, it is found to be often used in most articles. Most of the literature surveys were found to be narrative in nature. In quantitative methods, OR modelling comprising of multi-objective programming, linear/non-linear optimization modelling and other mathematical algorithms are preferred tool (14.17%) of researchers in SCRM. Probability and Statistics is used to analyse the data mainly at operational and tactical level of problems like production and inventory management, demand uncertainty. Soft OR tools like Analytical hierarchy process (AHP), Systems thinking are finding useful for research in SCRM. Simulation methods are not uncommon for assessing and modelling supply chain risks (Zsidisin et al., 2004). Agent based simulation (Ex. Datta. et. al, 2007); Monte Carlo simulation (Wagner et al., 2009) and Discrete-event simulation (Manuj. et al., 2009) studies are found to be used for solving problems mainly at operational management level. Manuj. et. al. (2009) provides eight-step development process for the design, evaluation and implementation of logistics and supply chain simulation models. Mixed methods combining two research methodologies are also found in review (9.17%). Undoubtedly there is huge potential in developing quantitative models to make hard decisions in SCRM (Tang and Nurmaya Musa, 2010). System dynamics rarely used in SCRM can be best suited for studying dynamic supply chain problems holistically.

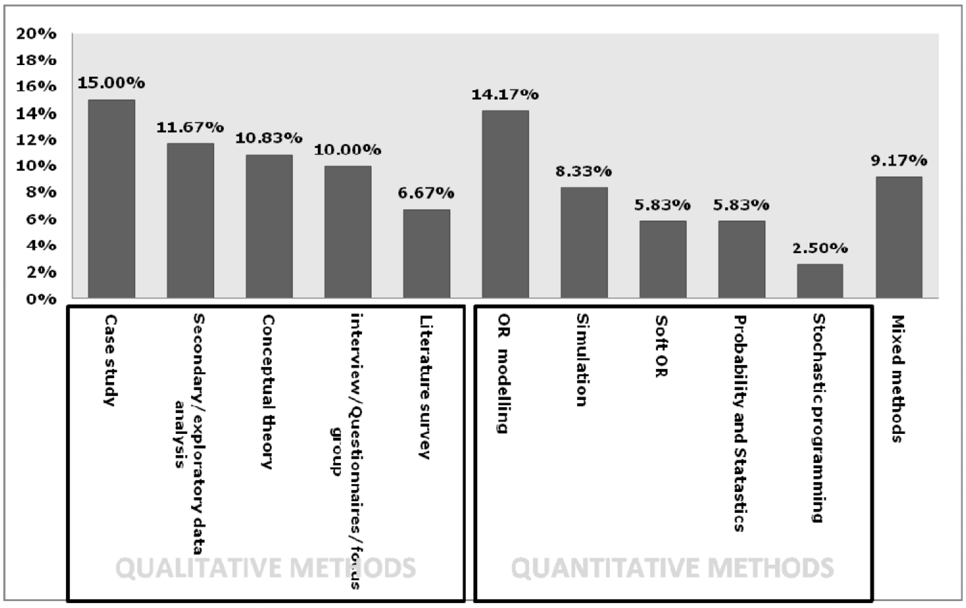


Figure 3: Preferred research methodologies in SCRM

Analysing the data from risk management (as a process) perspective, it is found that most of the articles focused on risk identification activity (35%). This clearly shows the nascent stage of researchers in SCRM. Very less attention is given to holistic risk management process. Only half of the articles analysed in SLR actually discussed about either implementing proactive or reactive risk mitigation strategies (61 out of 120). The approach to risk mitigation is preferred to be more proactive (58.33%) as compared to being reactive (23.33%). But, from a practitioners perspective it is vital but difficult to justify the investment in proactive risk mitigating strategies (Dani, 2008). Abundant scope for research in identifying and implementing robust proactive as well as reactive risk mitigation strategies is found in review.
Risk mitigation and control strategies were classified into two approaches as proactive and reactive. For holistic risk mitigation agility, flexibility and preparedness are

PROACTIVE RISK MITIGATION STRATEGY	REACTIVE RISK MITIGATION STRATEGY
• **Supplier development/management:** Risk sharing through contract manufacturing, contractual governance, Dual/multi sourcing. • **Supply chain Contracts:** Developing incentive contracts, Mix and volume flexibility contracts for risk mutual benefits, VMI/buffer stock. • **Product/process Management:** Product variety, postponement, product design and delivery management. • **Supplier relationship:** Supplier collaboration through improved confidence, cultural adaptation, Continuous coordination. • **Strategic planning:** Redesigning strategies, use of ICT technologies, Intellectual property transfer agreement.	• **Contingency planning:** strategic event management plan, enhanced flexibility in options. • **Disaster management:** Robust recovery, Rebuilding of Supply chain, resource utilization/management, Scenario analysis for future disruptions. • **Demand management:** Operational Rerouting, shifting customer demand, dynamic pricing.

Table 4: Risk mitigation strategies in SCRM

preferred generic strategies. Key proactive and reactive risk mitigating strategies found are compiled in table 4. It is found that at strategic level, contingency planning and risk sharing outsourcing contracts are prominently used risk mitigation strategies. Use of multi-strategy approach like combining supplier alliance network with lead time reduction and/or recovery planning system (Tang, 2006) can be effective for mitigating situational disruptions/risks.

CONCLUSION AND FUTURE SCOPE

SLR of 120 quality articles is carried following research design adapted from Tranfield et. al. (2003). In spite the process of systematic review methodology is found to be time consuming and labour intensive, it is found to be driven by methodical process and provides strong evidence base. SLR has provided few critical insights into SCRM research. Data analysis of research done from year 2000 to 2010 by systematic screening of sources gave us confidence on expected quality of outcome. SLR is needed to propose a future research agenda (Torgerson, 2003). The extensive analysis of the selected papers showed new directions in the SCRM field. Some of the identified research gaps are mentioned below,

- There is no robust contingency/recovery planning strategies for unknown disruptions (For example: Volcanic ash disruption, nuclear radiation, weather, Epidemic disease, etc).
- Quantitative tools including systems thinking, system dynamics has potential to capture dynamic behaviour of holistic supply chain for making hard decisions in SCRM.
- Green/Sustainable supply chain practices needs focussed research to meet global compliance standards and demands enhanced reverse logistics activities for remanufacturing.
- Information and Communications Technology (ICT) is expected to drive future of SCRM and research lacked appreciating its benefits and its consideration in past research.
- Modelling of Risk propagation and recovery time for disruption will provide greater visibility in effective SCRM.

The systematic literature review has provided insights into the present and future scope of the SCRM field. This research expects to provide benefit to researchers and managers by giving an understanding of the length and breadth of the SCRM field. The authors hope that the identified research insights, gaps and future directions will encourage new research techniques to manage risks in globalized environment.

Note: Due to the restriction on length of this paper to 8 pages, it was difficult to cite all 120 papers used during SLR. Hence, only individual references cited in paper are provided in reference section.

REFERENCES

Altay, N and Green III. G. (2006) "*OR/MS research in disaster operations management*", European Journal of Operations Research, 175, 475-493.

Badger, D, Nursten, J, Williams, P. and Woodward, M. (2000) "*Should All Literature Reviews be Systematic?*" Evaluation and Research in Education, 14: 3, 220-230.

Bimrose, J., Barnes, S. Anne and Brown, J. (2005) "*A Systematic Literature Review of Research into Interventions for Higher Education*". Higher Education.

Chase, R.B., Jacobs, F.R. and Aquilano, N.J. (2006) "*Operations Management for Competitive Advantage*", 11th edition, McGraw-Hill, New York, NY.

Chopra, S. and Sodhi, M. (2004) "*Managing Risk To Avoid Supply Chain Breakdown*", MIT Sloan Management Review, 46(1), 53-61.

Christopher, M. and Peck, H. (2004) "*Building the Resilient Supply Chain*", The International Journal of Logistics Management, 15(2), 1-14.

Christopher, M. and Lee, H. (2004) "*Mitigating supply chain risk through improved confidence*", International Journal of Physical Distribution and Logistics Management, 34(5), 388-96.

Dani, S. (2008), *''Predicting and Managing Supply Chain Risks''*, in Supply Chain Risk: A Handbook of Assessment, Management and Performance, Ritchie, R.L. and Zsidisin, G., Springer.

Datta, P.P., Christopher, M. and Allen, P. (2007) "*Agent-based modelling of complex production/distribution systems to improve resilience*", International Journal of Logistics Research and Applications, 10(3), 187-203.

Denyer, D. and Tranfield, D. (2009) "*Producing a systematic review''*, Ch. 39, in Buchanan, D. and Bryman, A. (Eds), The Sage Handbook of Organizational Research Methods, Sage Publications Ltd, London, 671-89.

Ghadge, A., Dani, S. and Kalawsky, R. (2010) "*A Framework for Managing Risks in the Aerospace Supply Chain Using Systems Thinking*", Proceedings of the 5th International Conference on System of Systems Engineering, IEEE, Loughborough, UK.

Hilmola, P., Helo, P. and Holweg, M. (2005) "*On the outsourcing dynamics in the electronics sectors: the evolving role of the original design manufacturing*", Working paper, Cambridge.

Juttner, U., Peck, H. and Christopher, M. (2003) "*Supply chain risk management: outlining an agenda for future research*", International Journal of Logistics Research and Applications, 6(4), 197-210.

Lemmer, B., Grellier, R. and Steven, J. (1999) "*Systematic review of non-random and qualitative research literature: Exploring and uncovering an evidence base for health visiting and decision making*", Qualitative Health Research 9 (3), 315–328.

Manuj, I., Mentzer, J.T. and Bowers, M.R. (2009) "*Improving the rigor of discrete-event simulation in logistics and supply chain research*", International Journal of Physical Distribution and Logistics Management, 39(3), 172-201.

Petersen C. G., Aase. G. R. and Heiser. D. R. (2011), "*Journal ranking analyses of operations management research*" International Journal of Operations and Production Management Vol. 31 No. 4, 2011 pp. 405-422.

Rao, S. and Goldsby, T.J. (2009) "*Supply chain risks: a review and typology*", The International Journal of Logistics Management, 20(1), 97-123.

Rousseau, D.M., Manning, J. and Denyer, D. (2008) "*Evidence in management and organizational science: assembling the field's full weight of scientific knowledge through syntheses''*, The Academy of Management Annals, 2(1), 475-515.

Rowe, W.D. (1980), "*Risk assessment: approaches and methods*", in Conrad, J. (Ed.), Society, Technology and Risk Assessment, Academic Press, London.

Sheffi, Y., (2005) "*A Supply Chain View of the Resilient Enterprise A Supply Chain View of the Resilient Enterprise*", MIT Sloan Management Review, 47(1).

Sodhi. M. S., Son B-G and Tang C. S, (2011) "*Researchers' Perspectives on Supply Chain Risk Management*", Production and Operations Management, in press.

Stefanovic, D., Stefanovic, N. and Radenkovic, B. (2009) "*Supply network modelling and simulation methodology*", Simulation Modelling Practice and Theory, 17(4), 743-766.

Tang, C.S., (2006) "*Perspectives in supply chain risk management*", International Journal of Production Economics, 103, pp.451-488.

Tang, O. and Nurmaya Musa, S. (2010) "*Identifying risk issues and research advancements in supply chain risk management*", International Journal of Production Economics, in Press.

Torgerson, C. (2003) "*Systematic reviews*", London: continuum.

Tranfield, D., Denyer, D. and Smart, P. (2003) "*Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review*", British Journal of Management, 14(3), 207-222.

Vanany, I., Zailani, S. and Pujawan, N (2009) "*supply chain risk Management: Literature review and Future research*", Int. Journal of Information Systems and Supply Chain Management, 2(1), 16-33.

Wagner, S.M., Bode, C. and Koziol, P. (2009) "*Supplier default dependencies: Empirical evidence from the automotive industry*", European Journal of Operational Research, 199(1), 150-161.

Zsidisin, G.A., Ellram, L.M., Carter, J.R. and Cavinato, J.L. (2004) “*An analysis of supply risk assessment techniques*”, International Journal of Physical Distribution and Logistics Management, 34(5), 397-413.

SECTION 5 – SUPPLY CHAIN DYNAMICS AND INVENTORY MANAGEMENT

MEASURING THE SPATIAL ORGANISATION OF AN AUTO-PARTS RETAIL NETWORK

Prem Chhetri, Brian Corbitt, Kwok Hung Lau,
France Cheong and Booi Kam

School of Business IT and Logistics, College of Business,
RMIT University, Melbourne, Victoria, Australia.

ABSTRACT
This paper aims to identify areas of economic value and to analyse spatial variability of demand and services delivery patterns for an auto-parts retail network. The spatial analysis undertaken was based on transportation and delivery of products out of 'point of sale' stores to customers. The revenues generated *in situ* were not accounted. Results show that the customer demand in terms of revenue tends to spatially skew, however the service delivery pattern reflects uniformity. This 'spatial mismatch' indicates inefficiency between value generated and trips made, leading to increased costs for delivery relative to value. Furthermore, the market areas that have been delineated for each of the stores also shows significant overlap – the area where stores compete with each other for business. Eighty percent of customers can be reached in 15 minutes radius; whist only 20 percent lies outside the market area. The identification of areas of economic value is a vital business strategy to reduce cost and increase revenue through which customers with the greatest potential can be geo-targeted. The outputs from this research have been used to rationalise the adoption of an area-based delivery strategy through which less accessible, unprofitable and non-critical customers can be either charged or outsourced without a substantial reduction in revenue or quality of service delivery.

Keywords:
Spatial organisation, Market area, geographic information systems and retail network

INTRODUCTION
The characteristics of a retail network can be analysed and modelled in a spatial context. In this research, a typical retail network at the downstream end is considered to comprise a set of retail stores, distribution centres, customers and the network that connects them together to represent a spatial system within which they interact. The optimality of that system depends on the way these elements are spatially organised and functionally integrated.

Using a geographical approach, this paper applied a range of spatial analytical tools to formulate and structure space in a way that it can be served optimally through the creation of market areas attached to the stores, and optimised in a way that all customers within a given space are served at minimal delivery cost and time. Spatial organisation of retail network however subjects to a number of assumptions. Among them, the assumption of 'isotrophic surface' – that is uniformity in all orientations (e.g. terrain, accessibility, demand, supply and competition) is fundamental to spatial modelling. The biophysical and socio-economic heterogeneity embedded in space relation is often considered to be constraints, which are often incorporated to undertake an optimisation routine.

This paper analyses spatial organisation of an auto-parts retail network in a number of ways. It captures the spatial organisation by mapping the geographic distribution of the retail network and the deviation of actual distribution pattern from the optimal structure (regular). Spatial analysis enables determining the number and spacing of stores in such a way that minimises delivery distance and thus costs. It reflects on the form of spatial variability in the demand pattern. For example, the demand could be spatially clustered or uniformly distributed across the network. Another manifestation of spatial organisation is the geographical demarcation of market areas in terms of sales territories and service network of stores.

This paper investigates solutions to delivery optimisation and cost issues for a cluster of stores. Using tools in Geographic Information Systems (GIS), this paper assesses areas of economic value, develops a delivery cost model, and makes recommendations towards a possible alternative distribution model. GIS is an information system technology that can be used to store and retrieve geographical data. The development of a delivery cost model allows the net profit or loss for each customer within the retail network to be computed; distant and clearly unprofitable deliveries to be identified and areas that are less accessible, unprofitable and non-critical to be delineated.

BACKGROUND
In after-service auto-parts market, products are distributed in a speed faster than ever seen before. Since, a large component of auto-parts businesses deals directly with consumers, thus delivering the orders in the right time, at the right place, in the right quantity and at the right price is paramount. The operational issues related to the 'last mile' that links stores and consumers, adds to additional complexity and are directly dependent on other echelons of supply chain. Broadly, the fulfilment process for consumer direct delivery can be represented in three stages: i) order acceptance; ii) order selection and fulfilment; and iii) order delivery (Campbell and Savelsbergh 2005; Delaney-Klinger et al. 2003).

The delivery of the final product to the customer's door is not only expensive but also logistically challenging. Boyer et al. (2004) estimated the costs for a single delivery of groceries run between $10 and $20 per order. The efficiency and responsiveness of the delivery system is space and time dependent. Space affects the way customers are distributed across an area in relation to stores and time affects delivery window length. A study by Boyer et al. (2004) expressed concern with increasing customer density to improve efficiencies and thus suggested a strategy to service focussed markets. Spatial structure represents a geographic state that affects the movement, flow, diffusion, interaction, linkage and accessibility to explain the way a typical retail network functions. On the other hand, delivery window length presents its own challenges when customers yearn for shorter delivery windows in contrast to companies striving for longer time windows to reduce costs.

Space organisation of a retail network is critical to the delivery of products as it regulates the way elements of a retail network are arranged, structured and organised that in turn affects costs and delivery time. For example, Federgruen and Zipkin (1984) evaluated a situation of one warehouse and multiple retailers to integrate the problems of product allocation and vehicle routing. Using a heuristic solution method, they split the main problem into a non-linear inventory allocation sub-problem and a number of traveling salesman sub-problems. Burns et al. (1985) compare two different strategies to improve distribution. First is the 'direct shipping' that break downs loads to each customer; and second is the 'peddling shipping dispatching vehicles' that deliver items to more than one customer per load. Examining the efficiency of a network with one origin, some intermediates and one destination, Bertazzi and Speranza (1999) propose a periodic shipping strategy to reduce the total cost of transportation and inventory. They proposed to operate the transport network from a central warehouse to several geographically dispersed retailers over a finite planning horizon. Assuming the demand remains retailer-specific and constant, stocks are suggested to be kept at the retailers but not at the warehouse, which means that the distribution system is ''coupled''.

There are studies galore that have developed a range of mathematical models, algorithms, and decision tools to improve the efficiency and responsiveness of a retail network. However, most of those tools have no or restricted spatial representation. They are predominately logistics rather than explicit spatial models. In this paper, we have used Geographic information system (GIS) to build spatial properties the auto-parts retail network. It provides the tools that can be used to manipulate, analyse and present geographical data. GIS provides a location intelligence tool for routing people, products and resources. It provides route optimisation solutions to maintain high service levels and cost effectiveness of service dispatch, fleet management and delivery response.

RESEARCH METHODOLOGY

In this section, we have captured the spatial configuration of the retail network, described the dataset that were used, and explained the methods that were applied.

Defining spatial configuration of the auto-parts retail Network

In GIS, data can be stored as points, lines and polygons to represent spatial properties of features. For example, retail stores can be represented as point features, a road network as a line feature and a port precinct as an area feature. The retail network that is currently in operation for the organisation represents the spatial structure that consists of DCs, stores and customers and their interactions across multiple levels.

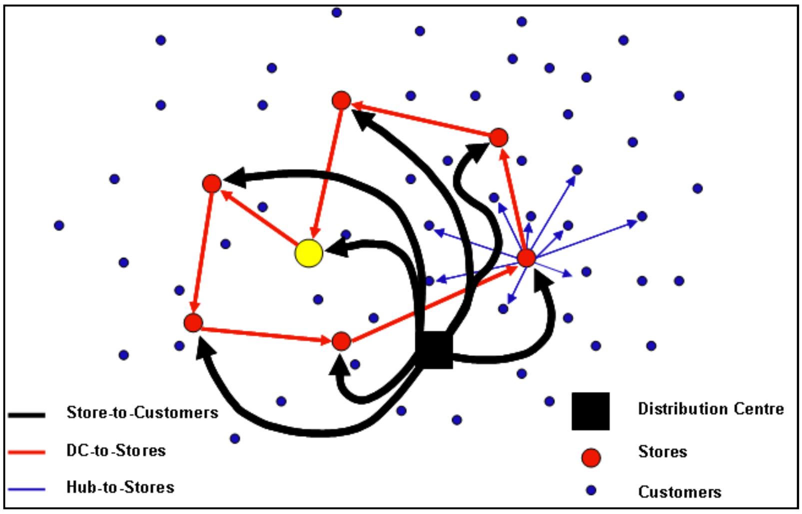


Figure 1: The spatial structure of the retail network

- In the first level (thick black lines), the distribution of auto-parts occurs from the distribution centre to stores. It could either take a form of one-to-one or a consolidated multi-trip delivery, depending upon the nature of the order.
- The organisation has recently adopted a hub-and-spoke delivery model, where the hub is designated to be fully replenished store; whilst spokes are partially replenished and are dependent on the hub for delivery. The second level of distribution (red lines) therefore connects the hub with stores, which could be structured on a fixed circuit route on a scheduled delivery with the capacity for minor adjustment to deal with JIT orders.
- The third level of distribution (thin blue lines) links stores with customers. It is the most critical element of the delivery system as it operates within a designated 'time window' and under a given set of performance criteria. The diagram therefore clearly illustrates the complexity of service delivery network to reflect the geography of distribution. It does not include the circulation that occurs at the upstream end of the supply chain. In this paper, the focus is largely at the level of store-to-customer.

Dataset used
The analyses were conducted on the sales data for a cluster of stores. It includes the details on invoices that were generated at a store level. The details include the value of invoice, the time when an order was received and products were delivered, the type of products, and the location and characteristics of customer base. The modelling and analysis undertaken was based on transportation and delivery of products out of 'point of sale' stores to customers. The revenues generated *in situ* were not accounted.

Methods
In this paper, we demonstrate the application of GIS tools in mapping the location of stores and customers, in representing the demand and service delivery patterns, in creating market areas, sales territories and service network. Using GIS, spatial characteristics of the cluster are mapped to evaluate the revenue and cost structures emanated from its current customer base. Spatial information stored in GIS illustrates the geometrical and topological relationships of objects or features that exist in a geographical space. Geometrical properties include positioning (latitude, Longitute), size (width, length and perimeter), shape and structure of features; whilst the topological properties captures continuity, adjacency, connectivity and containment. GIS also allow data to be processed for geostatistical analysis whereby various statistical and mathematical operations can be implemented. A number of spatial analytical techniques such as thematic mapping, network modelling and spatial statistics, were employed to visualise the underlying economic geography of the retail network for the organisation to evaluate the revenue and cost structures of its current customers.

SPATIAL ANALYSIS
The findings are presented in this paper to directly answer the research questions posed earlier in section 1. We begin the analysis by mapping the retail network and then present outputs of the spatial analyses.

Are all customers equal or are some more equal than others?
The data that we have obtained from the organisation were not spatially referenced. It contained transactions for a period of 12 months. Since the data consist of multiple transactions from one customer, it requires aggregation by customers' locations. Core sales data, consisting of each generated invoice, are aggregated at a customer level so that the total invoices *vis-à-vis* total sales for the given period of time can be computed. The customer locations are then geocoded as a set points (latitude and longitude) using address field as a unique identifier.

The question – *are all customers equal or are some more equal then others*, is explored through mapping the demand patterns. We have applied a method of thematic mapping to spatially represent a theme, which is the total sale volume in dollar terms. The method illustrates spatial variation of demand at a customer level for the retail network. The data can be mapped using techniques such as Choropleth, Isarithmic, dot and flow map. In this paper, we have adopted the proportional symbol technique that uses symbols of different sizes to represent data associated with different areas or locations. The dots/circles on the map in figure 2 represent customers – the demand nodes, which are depicted on the map through a proportional circle technique. The bigger the size of the circle the greater the revenue generated by that customer. It is therefore possible to spatially differentiate customers on the basis of revenue that they generate. Thus, due to the demand variability, some customers might be considered to be more important than others.

Are customers being served equally or are some being served more than others?
This question has been answered by mapping the frequency of demand - defined as the number of deliveries made within a specified period. The blue circles on the map in Figure 3 represent the number of delivery trips to customers from stores. The larger the

blue circle the greater the number of trips to a customer. Stores in some areas are economically more viable because they show a greater concentration of trips with high sales volume. On the other hand, there are other areas where customers are widely dispersed over a large area, which means longer trips and longer distances to be covered by stores.

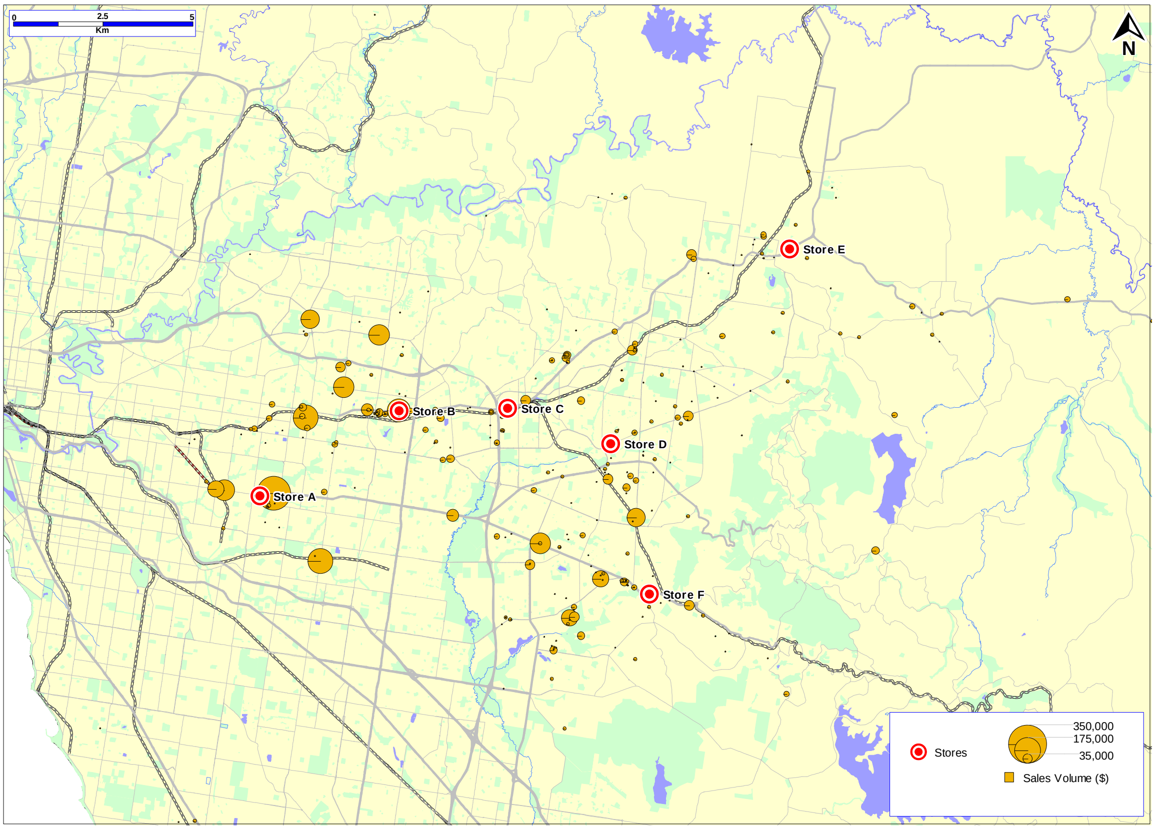


Figure 2: The spatial variability in demand pattern

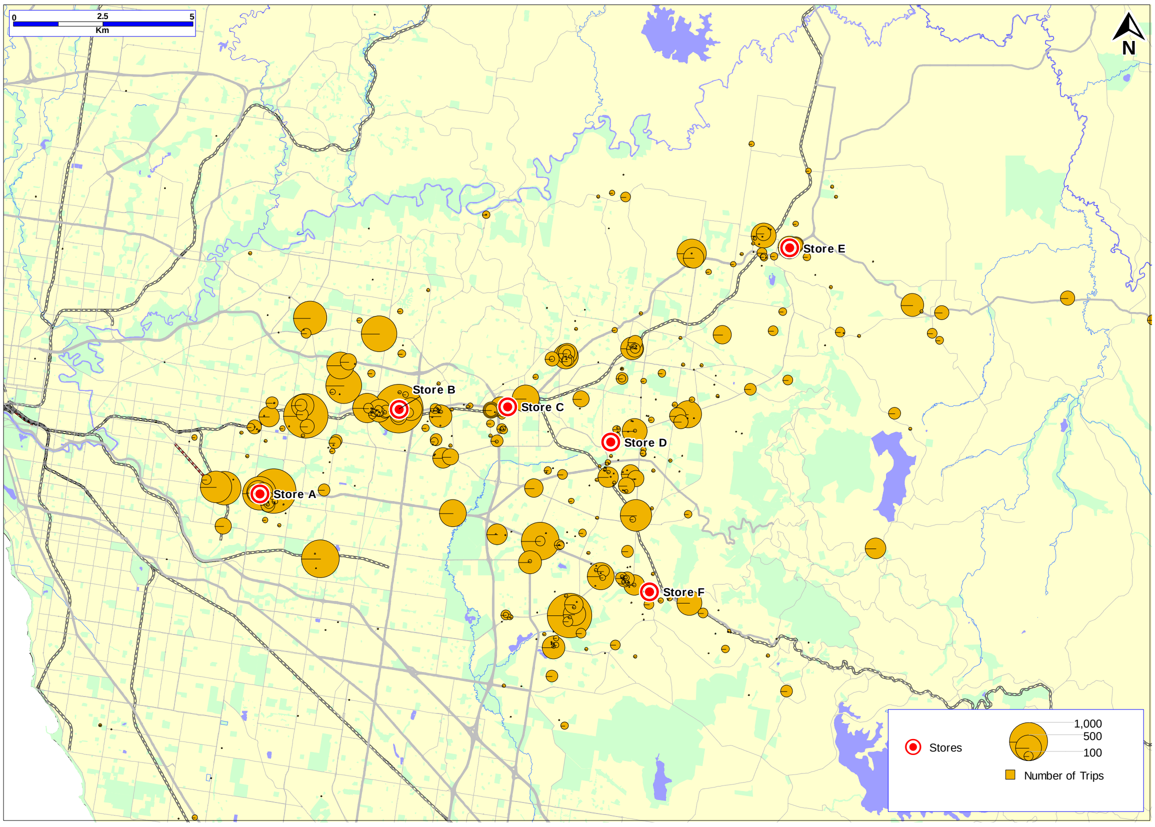


Figure 3: The spatial variability in service delivery

A combination of figures 2 and 3 identifies areas where customers have high frequency of delivery but low total sales as well as areas of low frequency of delivery but high total sales. It can be asserted that some customers have many deliveries though they produce low sales volume and *vice versa*. It also highlights the demand (sales) is skewed in one part of the region but that is not reflected in the pattern of trips. This indicates inefficiency in the relationship between value generated and trips leading to increased costs for delivery relative to value.

Are customers being served by the closest store?

The transaction data contained the name of the store where the invoice was generated. Using the network analysis tool, the closest store for each customer within the retail network was computed. Shortest route from store to customer was calculated and then latter incorporated in the sale data. It enabled us to examine whether the transaction occurred at the closest store. For the purpose of mapping, each customer (point) is colour coded to compare whether it was served by the closest store. For example, customers that are coded with red colour represent patronage to a store coded in red as shown in Figure 4. In this way, it is possible to determine whether customers are being served by the closest store or being served by multiple stores. Two major observations can be made through this analysis. First, there are numerous cases were customers are not been served by the closest stores; second, there are customers who have been served by multiple stores, in some cases, as many as six stores.

Total distance travelled to deliver goods in the study period was also computed. It is assumed that the optimised delivery system is a state where a customer is served by the closest store. The shortest distance to the closest store computed for each customer could then be used as a benchmark. The difference between the actual distance travelled and the distance to the closest store could indicate the levels of wastage in the delivery. Using the delivery cost per kilometre, the total delivery cost for the network is estimated.

If customers are served by the closest store, the delivery cost could be reduced by about 11 percent.

Do Stores have Optimal Market Areas?

A market area is the surface over which a demand or supply offered at a specific location is expressed. The market area of a retail store, for example, is the tributary area from which it draws its customers. One of the techniques used to delineate market areas is to establish links through which a customer is connected to a store or multiple stores. The size of the market area of a store is the catchment that it serves. For instance, the market area of store B, for instance, is an area represented through links coloured red, as shown in Figure 4. The intensity of lines emanating from each store indicates its topological structure. The greater the intensity, the greater the interaction and the number of customers being served. It also shows the distribution in terms of directionality. Some market areas are quite circular so they are serving in all directions. The mapping also reveals the spatial configuration of market areas. Some market areas are more compact in terms of shape; whilst others are more skewed due to the effect of topography.

Another common method through which market areas can be delineated is the computation of drive time for a store on the transportation network. Drive time enabled us to accurately create catchment boundaries (isochrones) based on driving time or driving distance. The purpose is to compute the market area of a store that it covers within a designated range. We have set this range to a 15-minute drive time. Distances and routes are calculated to take full account of speed limits, and other road restrictions such as railway crossing. Figure 4 shows the delineated boundaries for each of the stores. For example, the market area for store B is the area defined through a blue coloured line. Other things being equal, it is an area that can be served within the 15-minute drive time from the store.

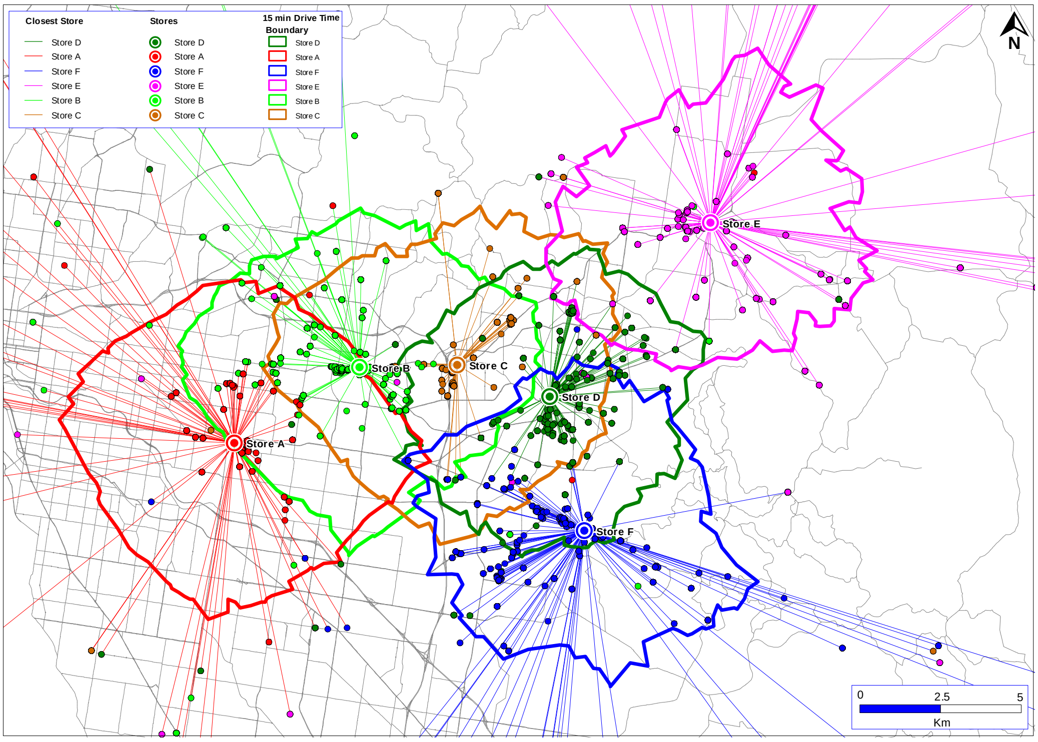


Figure 4: Customer patronage and market areas

The market areas delineated for each of the stores shows significant overlap, where stores compete with each other for business. For example, the distance from Store C to Store D takes about 8 minutes so each store is probably competing for the same set of customers. This might indicate that there are too many stores in this region. The analysis also shows that 95% of trips to customers are within the 15-minute drive time leaving only 5% outside the range of 15 minutes from the delivering store. Similarly, 94% of sales are within the 15-minute drive time and 6% outside this range. However, customers within and outside the 15-minute drive time clearly demonstrate the Pareto Principle or 80-20 Rule that 80% of customers can be reached in 15 minutes and 20% are outside the 15-minute range.

Are there profitable and unprofitable deliveries?
The answer to this question is extracted through building a delivery cost model. The model allows the net profit or loss for each customer within the retail network to be computed; distant and clearly unprofitable deliveries to be identified and areas that are less accessible, unprofitable and non-critical to be delineated. The disaggregation at the customer level is the innovative aspect of the model as it computes whether an individual customer is making profit or loss for the company. The model has been developed under the assumption that the delivery system operates on a point-to-point basis: delivery is the prime purpose of the trip and road network impedance is minimal. The delivery cost model begins by calculating the actual distance travelled on the transportation network from stores to customer over the study period. However, some adjustment has been made through the use of an invoice-delivery ratio to reduce the potential error generated through the one-trip-one-invoice model. Given the mileage of existing fleet operating within the network and the cost of fuel, labour and vehicle ($1.44 per km), the actual distance in kilometres is then converted into cost per kilometre. This figure gives us the cost of delivery for each customer. Using the state wide margin, a gross profit for each customer within the network is calculated as the margin on total sale value of the invoice. The delivery cost is then deducted from gross profit to calculate net profit or loss. It has identified the unprofitable customers as well as highlighted the areas where the delivery cost exceeds the margin. The customers that are unprofitable are mapped and are found to be located largely outside the market areas. The results show that the demand generated from these non-critical customers is also relatively low.

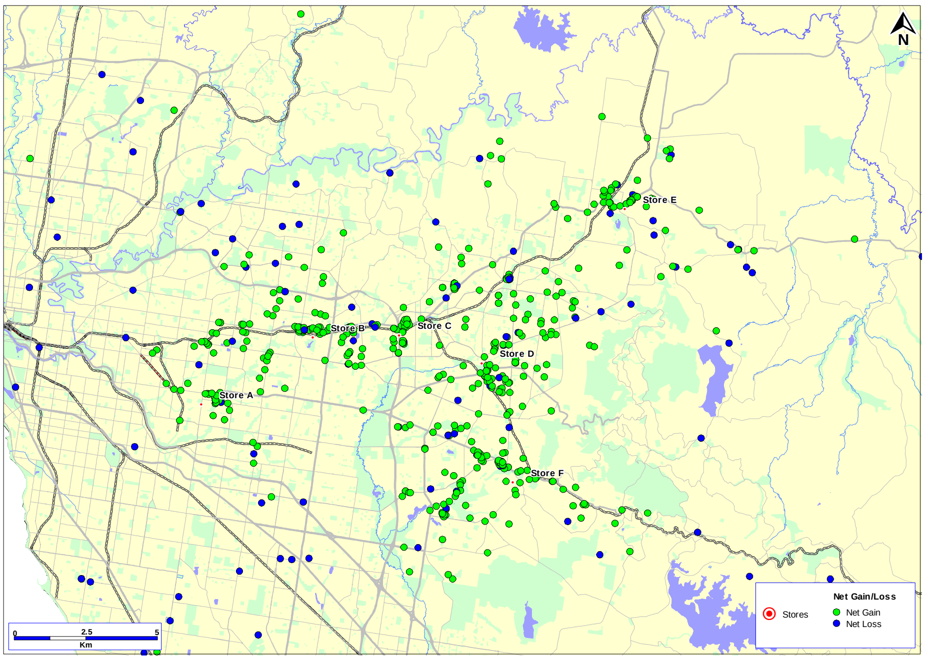


Figure 5: areas of economic value

CONCLUSIONS
The application of spatial analytical tools has generated outputs that provide a spatial perspective on the responsiveness of an auto-parts retail network to demand. The 'spatial mismatch' indicates inefficiency between value generated and trips made, leading to increased costs for delivery relative to value. Customers are also being served by stores in areas where they shouldn't be served because the value of items that are

purchased by these customers do not compensate for the cost and time incurred by drivers to deliver the goods. The results produced through this model highlight the need to realign the distribution strategy to minimise the delivery costs to those customers that are clearly unprofitable. The results demonstrate the need to prioritise customers and create strategies for differential levels of service delivery.

REFERENCES

- Arvis, J., Mustra, M., Panzer, J., Ojala, L. and Naula, T. (2007) *Connecting to Compete - Trade Logistics in the Global Economy: The Logistics Performance Index and Its Indicators*, The World Bank, www.worldbank.org/lpi, accessed 7/7/09.
- Chhetri, P., Corcoran J. and Hall M.C. (2008), Modelling the spatial patterns of tourism-related employment for South East Queensland – A spatial econometric approach, *Tourism Recreation Research*, 33 (1): 25-38.
- Grossman, H., Otto, A., Stiller, S. and Wedemeier, J., (2007) Growth potential formarine trade and ports in Europe, *Intereconomics*, July/August, pp226-232.
- Laird, P. (1992) Rail freight development in Australia, *Logistics and Transportation Review*, 28(3), pp273-287.
- Mollenkopf, D. and Dapiran, P. (2005) World-class logistics: Australia and New Zealand, *International Journal of Physical Distribution and Logistics Management*, 35(1), pp63-74.
- Robinson, R. (2006) Port-oriented landside logistics in Austalian ports: a strategic focus, *Maritime Economics and Logistics*, 8, pp40-59.
- Federgruen, P. and Zipkin, A. (1984) Combined vehicle routing and inventory allocation problem, *Operations Research,* 32 pp. 1019–1037.
- Burns, L.D., Hall, R.W., Blumenfeld, D.E. and Daganzo, C.F. (1985) Distribution strategies that minimize transportation and inventory cost, *Operations Research,* 33, pp. 469–490.
- Bertazzi, L. and Speranza, M.G. (1999) Inventory control on sequences of links with given transportation frequencies, *International Journal of Production Economics,* 59, pp. 251–270.

INVENTORY POLICIES OF MAINTENANCE SPARE PARTS: A RISK MANAGEMENT MODEL

Francesco Costantino, Margherita De Minicis, Giulio Di Gravio, Massimo Tronci
Department of Mechanical and Aerospace Engineering, University of Rome "La Sapienza"

ABSTRACT
The aim of the paper is to define an innovative model to determine and evaluate the best inventory policies of maintenance spare parts basing on a risk management approach. The model determines if spare parts have to be stored and in what quantity, according to an evaluation of stock-out and stock keeping risks. The formulation is applied and validated to a specific case study of a pharmaceutical production line.

Keywords:
Spare parts inventory, stock out risk, stock keeping risk, fuzzy approach, probabilistic approach

Introduction

Spare parts management is an always actual issue of discussion ([6], [9], [10]) as its incidence on maintenance can go from 15% to 40% of the total costs. Only a complete set of information on reliability of machines and components, reliability of suppliers, costs and processes of purchase could support to determine the best strategy of management, in particular on stocking and ordering policies ([12], [14])).
Knowing failure modes of systems allows to get the necessary data to help recognizing:

- occasional failures, not related to specific causes but to accidental events, not possible to forecast;
- recurrent failures on infantile mortality or degradation of the components, generally controlled by opportune methodologies of failure rates analysis.

Studies on reliability ([4]) put the basis of the maintenance programs through an estimation and classification of criticalities so to correctly define priorities on:

- *Special parts*, generally used in planned maintenance, to be acquired and ready just at the beginning of the interventions;
- *Controllable wear parts*, generally controlled under predictive or condition maintenance, when it's possible to identify signals of deterioration in advance and issue orders to suppliers before breakdowns, according to their lead times;
- *Spare parts*, for accidental and unexpected failures, with high costs of production loss compared to stock keeping costs.

This general classification requires organizations to act a process of continuous improvement to increase levels of efficiency, reducing wastes and avoid unnecessary costs. Furthermore, organizational and production strategies, behaviours of suppliers, new standards and directives are significant factors that can contribute to change spare parts management policies.
This strong relation with the "management of uncertainty" requires a systematic approach to risks to identify all the events that can affect performances and determine actions to prevent and protect the organization itself, its market and environment.

Risk Management approach to spare parts

The purpose of this paper is to present a risk management model to identify the best strategy of spare parts management basing on an evaluation of stock-out and stock-keeping risks. This approach is an evolution of the traditional methodologies that, starting from an extension of inventory management models, introduce different analytic techniques (i,e, queue theory) to describe causes and effects of failures ([1], [2], [5], [7], [8], [11], [18]).
In particular, stock-out risk and its impact is the key factor to shift from an "on order" policy to an "in stock" and define the right quantity to keep in accordance to performance

targets of efficiency and effectiveness. Stock-outs increase time to repair of failures, determining costs of production losses (if not penalties) and, at the same time, inactivity of human resources of operations and maintenance. If supply orders have to be issued in priority or emergency, this can also increase administrative, purchase and distribution costs, sometimes preferring fast suppliers despite their quality. On the other hand, stock keeping or obsolescence costs represent an opportunity cost that can strongly affect budgets and has to be accurately evaluate ([13], [15], [16], [17]).
Even once defined the level of each component is stock, a stock-out can anyway happen, due to uncertain issues:

- errors in forecasting failures, planning maintenance and elaborating diagnostics on performances of machines;
- delays of shipments;
- mistakes in purchasing or coding processes;
- defective components already in stock;
- obsolescence or wrong conservation of components.

To avoid stock-outs it’s so necessary to take in consideration all these aspects to accurately forecast the demand of spare parts and acquire them just in time for the execution of interventions.

Risk Evaluation

Once defined *stock-out risk* and *stock-keeping risk*, a method of evaluation is needed to identify critical components of machines and their eventual level of stock. In this case, the “product rule” can be applied, according to the following formulation:

$$RISK\ SCORE = PROBABILITY * IMPACT$$

A simple comparison of the score of the two risks, evaluated for any part under in study, can suggest the right management strategy:

- if $RISK\ SCORE_{stock-keeping} < RISK\ SCORE_{stock-out}$ then the part has to be taken in inventory with a level to calculate;
- if $RISK\ SCORE_{stock-keping} > RISK\ SCORE_{stock-out}$ then the part can be ordered on requirement.

As the nature of the different impacts that contribute to the Risk Score is generally heterogeneous, on different dimensions of performances, tangible or intangible, qualitative or quantitative, and with a certain degree of uncertainty, the evaluation needs to take into account judgements of experts. Furthermore, benchmarking analysis are limited as the same aspects can assume relevant values depending on the reality, contexts and environment to analyse. For these reasons, the application of the fuzzy logic to risk management allows to treat the variety of input information in coherent fuzzy data to aggregate and combine with a set of IF-THEN-ELSE rules and finally decode the results in a crisp output ([3]). Any specific case study can be so described with this methodology to opportunely represent the risk profile and preferences of the organization, as discussed later.

Probability evaluation

Supposing not to have any spare part in stock and to order only on requirement of a maintenance intervention, the probability of stock-out is equal to the probability of failure of a component, according to its failure rate.
For each component, it’s to identify a probability density function of failures $f(t)$ and a rate of failure $\lambda(t)$ to represent the conditional probability of working at a certain time t. For not repairable systems that evolve between a working and a non-working state, the probability of failure in a given interval [t_0;t] is:

$$P_{failure}(t) = \int_{t_0}^{t} f(\tau)d\tau \ = 1 - R(t),$$

where *R(t)* is the reliability of the component. Consequently:

$$P_{failure} = P_{stock-out} = 1 - R(t) = 1 - P_{stock-keeping}.$$

The calculation of how many parts to keep in stock so depends on the demand of the components and their failure rate. As the same part can be used on different machines with different levels of criticality, a Work Breakdown Structure of each element of the system can help to clarify their relative level of importance. The number of items to keep can be defined evaluating the risk of stock-out for the different values of stock until an acceptable level. As the impact of a stock-out can be considered invariant, it's the probability that changes the score. Not considering defects of quality, errors in coding and obsolescence of components (significant only under specific conditions and in complex systems), the probability of an item to remain in stock is described by a binomial function:

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

where:
n number of items of the same kind in the system;
k number of items to substitute;
p probability of a failure (demand of items).

Supposing a purchasing process with a duration T, if in this interval there are no failures, none of the spare parts is so used otherwise the stock is decreased according to the number of interventions effectuated. If *j* spare parts of a single components are in stock, the stock-out probability is the probability of failure from *j+1* to *n* parts:

$$P_{stock-out}(j) = \sum_{k=j+1}^{n} \binom{n}{k} p^k (1-p)^{n-k}.$$

To determine a correct value of *n* it's possible to iteratively apply the model presented, recalculating stock-out and stock-keeping risks with a variation of parts in inventory. The process stops when the stock-out risk passes a threshold level, according to the risk profile of the organization, or when:

$$RISK\ SCORE_{stock-keeping} > RISK\ SCORE_{stock-out}.$$

The case study

The model was realized to define the spare parts management strategies of a packing machine in a pharmaceutical plant, in particular of a production line for veterinary products. The machine is particularly critical for its low level of reliability and because of any stop is extended to the whole line with no possibility of work in process buffers. Furthermore, these specific products can be stocked for a very short period as they have a limited shelf life.

To reduce the effect of stock-outs in case of unexpected failures, it's possible to carry out a risk analysis on the critical components of the machine in a certain interval. In this case, the period of observation is the one between two planned interventions of maintenance, considering only the components under preventive maintenance as the others already present a sufficient re-order level. Time series showed long stops due to these stock-outs with a set of significant impacts, to describe in dedicated fuzzy sets, that can be summed up in:

- increase of purchasing costs;
- inactivity of human resources;
- delays in dispatching;

- loss of production.

The increase of purchase costs can be evaluated considering the percentage increase of the price of the part for an emergency situation. The dominion of the costs is defined in a [0%; 50%] interval, according to the real market conditions and the budget rules of the organization (fig.1).

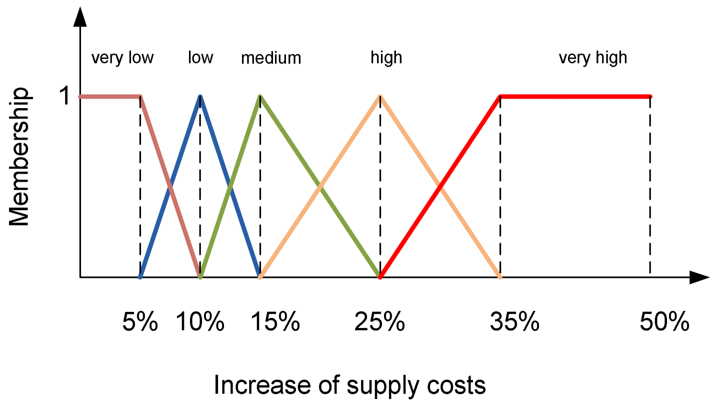


Figure 1 – Increase of supply costs fuzzy set

When the production stops for a failure, workmen can be reallocated on different operations or lines to avoid losses of production time. At the same time, if the spare part is not in stock, also maintenance personnel has to be reallocated until the part is available for the intervention. At best, if this happens in few hours, only a shift could get lost but, in worst cases, waits can last for days so to force closing time and limit costs of inactivity (fig.2).

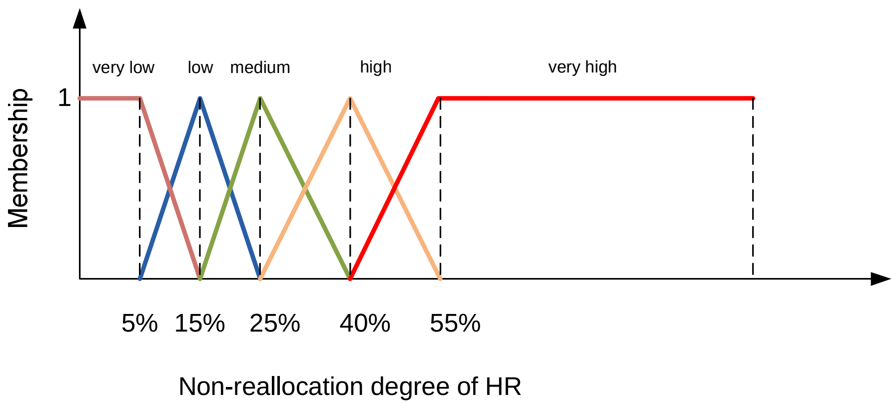


Figure 2 – Reallocation of HR fuzzy set

At the same time, the increase of costs for loss of production is a time-linear function of about 1000€/h for any stop. Also in this case, there is the possibility to reschedule activities and recuperate time avoiding planned stops and extending shifts. The fuzzy set is so the same of human resources reallocation.
In the end, penalty costs due to missed dispatches have to be considered, depending on the contractual clauses and the time of stop of the line (fig.3).
After having completed the characterization of the variables of the problem, it’s possible to evaluate the impact of stock-out risk through a set of inference rules. The 4^5 rules, derived from all the possible combinations of the 5 levels of linguistic expressions of the 4 variables, have to be build according to a relative degree of influence of the dimensions of impact on the total risk:

$$IF\ supply\ AND\ inactivity\ AND\ losses\ AND\ delays\ THEN\ Impact$$

A pool of experts agreed on a low significance of supply costs, high significance for inactivity and delays and critical significance for production losses to derive the risk profile of the organization. The degree of activation of each rule is then due to the specific membership values that any part presents on each dimension of impact.

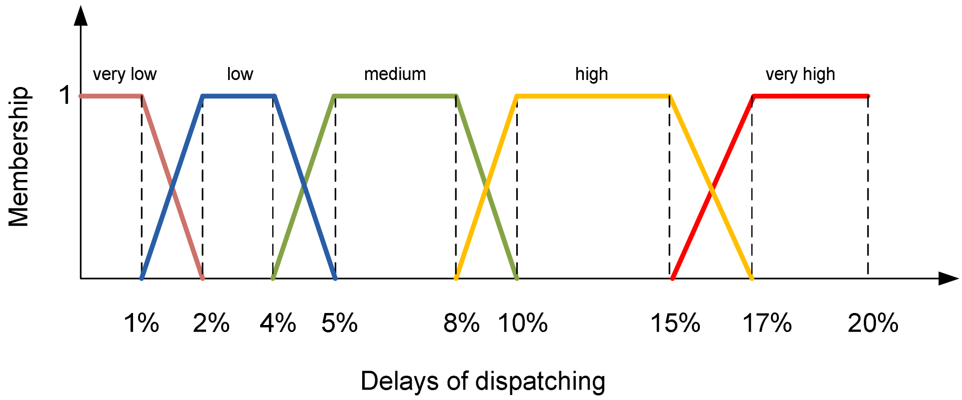


Figure 3 – Delays of dispatching fuzzy set

The fuzzy set of Impact is instead a standard set of five linguistic value (very low, low, medium, high, very high) with triangular membership functions, symmetrically disposed on a 100 points base. A "centre of maximum" algorithm can so generate crisp values from the different results of the activated rules to weight their contributions.

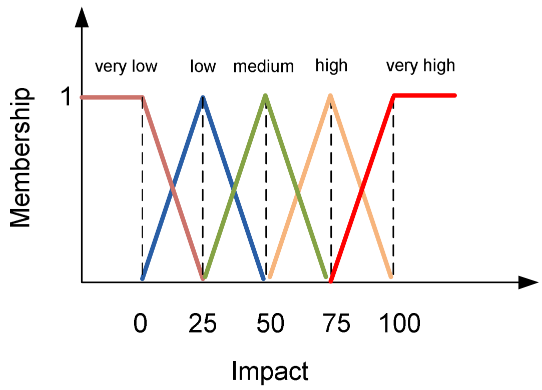


Figure 4 – Impact fuzzy set

Associating the relative probability of stock-out (according to the actual inventory level of each component) it's possible to evaluate the score for the stock-out risk (tab.1).
Keeping a spare part means use resources to manage inventory, grant environmental conditions to protect inventory and bear costs of capital for a total cost of about 10% a year of the purchasing cost of the component (fig.5). Furthermore, it's also necessary to associate an indication on the risk of obsolescence of the part that can be qualitatively estimated on the same five-level scale.
To create the inference rules, obsolescence is considered critical as, in case of waste, there is a further cost of treatment to bear. The evaluation scheme for the stock-keeping risk is so the same of the stock-out risks (tab.2) and it's so possible to give an indication on the policy of supply comparing the values of the two risk scores.

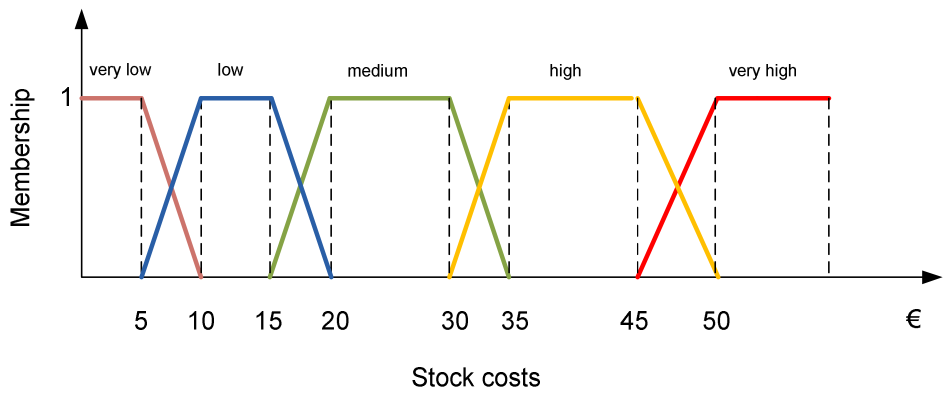


Figure 5 – Stock costs fuzzy set

Table 1 – Stock-out Risk Score

PART	Supply	Inactivity	Delays	Losses	IMPACT	PROBABILITY	RISK SCORE
Bearings	5%	5%	0%	5%	8,33	0,38	**3,17**
belt	15%	15%	8%	15%	33,33	0,2	**6,67**
blade (x14)	10%	5%	0%	5%	33,33	0,25	**8,33**
induction motor	25%	12%	3%	12%	44,91	0,1	**4,49**
pump (x2)	30%	20%	6%	20%	58,33	0,05	**2,92**
tape (x2)	15%	5%	0%	5%	8,33	0,4	**3,33**
tape roll	10%	5%	0%	5%	8,33	0,05	**0,42**
transmission belt (x2)	15%	5%	0%	5%	8,33	0,22	**1,83**
transmission chain	20%	30%	10%	30%	50	0,07	**3,5**
transmission gear	25%	30%	10%	30%	50	0,3	**15**

Table 2 – Stock-keeping Risk Score

PART	Stock	Obsolescence	IMPACT	PROBABILITY	RISK SCORE	POLICY
bearings	0,9	Low	0,33	0,62	**0,20**	in stock
belt	2,25	Very low	8,33	0,8	**6,66**	Indifferent
blade (x14)	3	Very low	8,33	0,75	**6,25**	in stock
induction motor	13,5	High	66,67	0,9	**60**	on order
pump (x2)	45	High	91,67	0,95	**87,09**	on order
tape (x2)	1,5	Very low	8,33	0,6	**5**	Indifferent
tape roll	2,3	Low	0,33	0,95	**0,31**	in stock
transmission belt (x2)	1,25	Low	0,33	0,78	**0,26**	in stock
transmission chain	9	Low	0,33	0,93	**0,31**	Indifferent
transmission gear	9	Medium	50	0,7	**35**	on order

CONCLUSIONS

The model is able to analyse a the strategic implications that drive organization to choose among different policies of spare parts management, integrating a fuzzy description of data in a formal of risk management. The uncertainty of decisional parameters at any stage is evident: most of the actions derives from a qualitative analysis of the situation but, in any case, experience, intuition, accidents play a fundamental role in determining the success level of the choices.

The structure of the production system, their complexity and uncertainty, the temporal variability and partial information of parameters need a framework to create an architecture for decision making able to evaluate the impacts of events and balnce them with their probability of happening.

The model represents a tool for analysis that can relate qualitative competencies with both quantitative and estimated information in a logic based on simple linguistic rules and components. It can be extended and refined evaluating the possibility of introducing further inputs (dimensions of impacts), eventually modifying the membership functions according to a standard set of risk profiles.

The generalization of the methodology presented in the case study, easy to apply, allows a natural implementation in all the strategic contexts where it is critical to identify and correctly manage spare parts, according to target times and performance levels. In particular, the same approach can be replicated in any problem of scarce resource allocation to identify and balance risk attitude towards inventory costs.

It is anyway evident how the fuzzyfication activity is the critic element to get the proper input for the system. The lack of a standard procedure and the necessary involvement of skilful users to evaluate classes and membership functions.

To adapt to different environment ask for a simplification and automation of the process. The possibility of giving to an expert system (knowledge-based or neural network-based) the activity of elaboration and formalization could increase notably the applicability of the framework, saving the end-user from errors in the decisional process, reducing risks of wrong interpretations and relieving from responsibilities.

BIBLIOGRAFIA

[1]. Chang P.L., Chou Y.C., Huang M.G. (2005), *A (r,r,Q) inventory model for spare parts involving equipment criticality*, International Journal of Production Economics, vol.97, pp.66-74.

[2]. Chelbi A., Ait-Kadi D. (2004), *Analysis of a production/inventory system with randomly failing production unit submitted to regular preventive maintenance*, European Journal of Operational Research, vol. 56, pp.712-718.

[3]. Costantino F., Di Gravio G. (2009), Multistage bilateral bargaining model with incomplete information - a fuzzy approach, International Journal of Production Economics, vol.117(2), pp.235-243

[4]. Duchessi P., Tayi G.K., Levy J.B. (1993), *A conceptual approach for managing spare parts*, International Journal of Physical Distribution & Logistics Management, vol. 18(5), pp. 8-15.

[5]. Kalchschmidt M., Zotteri G., Verganti R. (2003), *Inventory management in a multi-echelon spare parts supply chain*, International Journal of Production Economics, vol.81-82, pp.397-413.

[6]. Kennedy W.J., Wayne Patterson J.W., Fredendall L.D., *An overview of recent literature on spare parts inventories* (2002), International Journal of Production Economics, vol. 76, pp. 201–215.

[7]. Leonardo P., Anghinolfi D., Paolucci M., Tonelli F. (2008), *A stochastic linear programming approach for service parts optimization*, CIRP Annals - Manufacturing Technology, vol.57, pp. 441-444.

[8]. Lanza G., Niggeshmidt S., Werner P. (2009), *Optimization of preventive maintenance and spare part provisioning for machine tools based on variable operational condition*, CIRP Annals – Manufacturing Technology, vol. 58, pp. 429-432.

[9]. Mehrotra A., Natraj N.R., Trick M.A. (2001), *Consolidating Maintenance Spares*, Computational Optimization and Applications, vol.18, pp.251-272.

[10]. Rustenburg W.D., van Houtum G.J., Zijm W.H.M. (2001), *Spare parts management at complex technology-based organizations: an agenda for research*, International Journal of Production Economics, vol.71, pp.177-193.

[11]. Sana S., Goyal S.K., Chaudhuri K.S. (2004), *A production–inventory model for a deteriorating item with trended demand and shortages*, European Journal of Operational Research, vol.157, pp.357-371.

[12]. Sarker R., Haque A. (1999), *Optimization of maintenance and spare provisioning polity using simulation*, Applied Mathematical Modeling, vol.24, pp.751-760.

[13]. Sleptchenko A., Van der Heijden M.C., Van Harten A. (2005), *Using repair priorities to reduce stock investment in spare part networks*, European Journal of Operational Research, vol.163, pp.733-750.

[14]. Vaughan T.S. (2003), *Failure replacement and preventive maintenance spare parts ordering policy*, European Journal Of Operational Research, vol.161, pp.183-190.

[15]. Verrijidt J., Adan I., de Koka T. (1998), *A trade off between emergency repair and inventory investment*, IEE Transactions, vol.30, pp. 119-132.

[16]. Wong H., Van Oudheusden D., Cattrysse D. (2007), *Cost allocation in spare parts inventory pooling*, Transportation Research Part E, vol.43, pp. 370-386.

[17]. Wu M.C., Hsu Y.K. (2008), *Design of BOM configuration for reducing spare parts logistic costs*, Expert Systems with Applications, vol.34, pp.2417–2423.

[18]. Zohrul Kabir A.B.M., Al–Olayan A.S. (1994), *A stocking policy for spare part provisioning under age based preventive replacement*, European Journal of Operation Research, vol.90, pp.171-181.

COLLABORATIVE SALES PLAN AMONG FARMERS AND DEVELOPMENT OF ARRIVAL AND SALES PLANNING SUPPORT SYSTEM IN FARMER'S STORE

Ken Shimokawara[1], Takeo Takeno[1], Mitsuyoshi Horikawa[1],
Masaaki Ohba[2] and Mitsumasa Sugawara[1]
[1]Graduate School of Software and Information Science Studies,
Iwate Prefectural University, JAPAN
[2]College of Economics, Nihon University, JAPAN

ABSTRACT
Farmer's store is a place where farmers directly sell regional agricultural products to consumers by themselves. They place their products at a certain shelf before the store opens. Thereafter, they occasionally check the stock and replenish new products according to the sales. On the one hand, they work as sales-staff and receptionist in the store by turns. Consequently, they can reduce distribution cost and make more profit out of it compared with the general contract sale through intermediates.

Currently, Farmer's store have competed each other, because the market has been expanded by new market entrants. Therefore, they need to work on obtaining a wider selection of products in the store so as to improve consumer service. In order to secure a wide selection of products in the store, the store must take into consideration of fluctuations in quantity and price through natural environment as well as temporal and informational restrictions of decision making. Therefore, they need to work on adjusting arrival of varieties and quantities from planting stage, and mutual supplemental method among farmers to meet the expected fluctuations of supply and demand as one entity. Particularly, at the store where farmers take the leadership in the management, it is difficult to control the solid throughout management strategy, because farmers have decentralized themselves as decision makers. These cause opportunity losses and over stocks of the store.

The purpose of this study is to support farmer's decision making to satisfy consumer demands. We clarify decision making structure, and propose mechanism of decision making support system in order to obtain voluntary quantity adjustment. Thus, we have developed an Arrival and Sales Planning System to support sales plan making for farmers and store's manager in the farmer's store. Arrival plan shows monthly arrival quantity and the highest and the lowest selling prices of each farmer.

The proposed system provides following functions: 1) arrival planning by the farmers and 2) sales plan making based on the arrival planning. As for sales plan making based on the arrival planning, the system supports to integrate arrival plans of individual farmer, proposes a sales plan of the entire market referring to previous sales performance and demand estimate, and shows the proposed sales plan to the public on the web. The system makes it possible to grasp of each farmer's sales strategy, and to use it for management strategy of the store. Moreover, the consumers are able to check its peak season of products by the sales plans on the web.

We have operated the system in a certain farmer's store since April 2009. As a result, many farmers could obtain the better trend of sales for the specific products the method was installed. Furthermore, the method made it possible to secure a wider selection of seasonal commodities in their off-season. We carried out a questionnaire survey for the farmers. We found out about 70 percent of farmers were in favor of the system.

Key Words:
Supply Chain Inter-Firm Networks and Collaboration,
Decision Support Systems and Communication Technologies

INTRODUCTION

Farmer’s store is a place where farmers directly sell regional agricultural products to consumers by themselves. At the store, they need to work on obtaining a wider selection of products in the store so as to improve consumer service. Therefore, they need to work on adjusting arrival of varieties and quantities from planting stage, and on a mutual supplemental method among farmers to meet the expected fluctuations of supply and demand as one entity. Particularly, at the store where farmers take the leadership in the management, it is difficult to control the solid throughout management strategy, because farmers have decentralized themselves as decision makers. These cause opportunity losses and over stocks of the store.

The purpose of this study is to support farmer’s decision making to satisfy consumer demands. We clarify decision making structure, and propose mechanism of decision making support system in order to obtain voluntary quantity adjustment. Thus, we have developed an Arrival and Sales Planning System to support sales plan making for farmers and store’s manager in the farmer’s store. Additionally, we operate the system in the store and verify whether the system is an effective device.

In this paper, we summarize current distribution and decision making structure at farmer’s store in chapter 2. Chapter 3 shows decision making support for farmers. Proposal of arrival and sales plan support system is presented in chapter 4. Chapter 5 shows the implemented system. Finally, we give the conclusion in chapter 6.

DISTRIBUTION AND DECISION MAKING STRUCTURE AT FARMER’S STORE

Distribution channels of agricultural products exist in various ways in Japan. Figure 1 portrays distribution channels for agricultural products in Japan (Ose 2003). The farmer’s store has also become one of distribution channels for agricultural products.

In wholesale market, quantity and price of the products are adjusted through the contracts between farmers and JA (Japan Agricultural Cooperatives). On the other hand, farmer’s store is able to cut down distribution commission, because distributors are farmers themselves. Therefore, they can supply consumer with reasonably inexpensive and fresh agricultural products.

In farmer’s store, agricultural products are directly shipped from farmers, or by way of JA. A farmer’s store is composed of and managed by either, individual store, JA store, farmer group store or others.

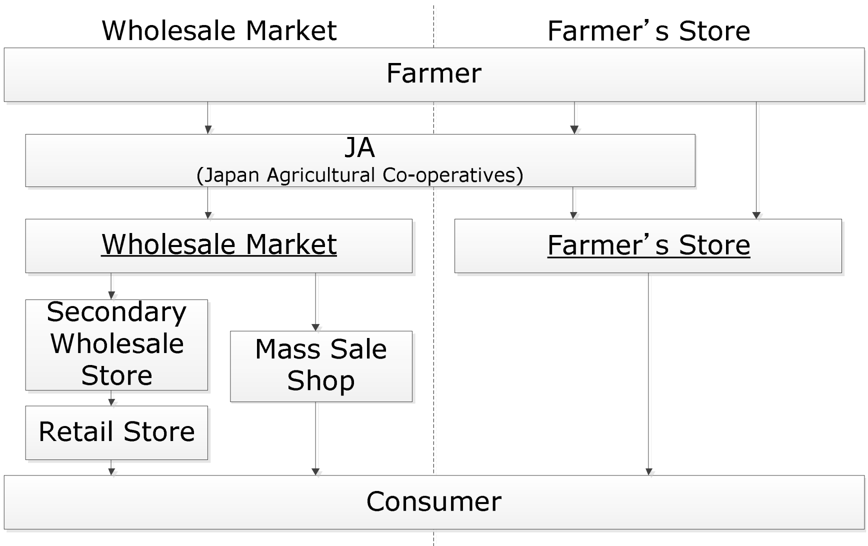


Figure 1 Distribution channel for agricultural products in Japan

At farmer's store managed by JA, JA as a base of distribution is responsible for necessary quantity adjustment and quality inspection. JA staff administers management of each store and employment issues. They also regulate production specification or method of cultivation, and guide farmers for a wide selection of products. Therefore, decision making structure is a top-down approach that JA officer comes at the top.

At farmer-group-store, farmers produce, circulate and sell the products by themselves. They meet and serve consumers by turns. Therefore, they have more flexibility in sales segment compared with the farmer's store where JA manages. They place several containers in the store. They occasionally check the stock and replenish new products according to the sales. At the store, they determine a sales manager by election. On the one hand, sales strategy is determined by farmers themselves, which is bottom-up decision making at the store. Therefore, it is difficult for the manager to control the solid throughout management strategy.

DECISION MAKING SUPPORT FOR FARMERS

There are precedents researches of decision making support for farmers in farmer's store. Nakajima (2005) and Shimakawa et al. (2008) developed agricultural products information management system used public database "SEICA". The system gives production information to consumer when the product is sold, and the system also feed-back sales and stock information to farmers. However, the system is targeted decision making support only for individual farmer, and it doesn't support information sharing among farmers for arrival adjustment as one entity.

We are proceeding this research as a cooperative project with purpose of making good use of information technology for a farmer's store. The project has been targeted at a farmer's store called "SANCHOKU AKASAWA" in Shiwa town, Iwate prefecture, Japan. The store is organized as Juridical Agricultural Union. It has 130 farmers, and sells apples and grapes as leading products. The store has been implemented inventory management and information-related education for farmers by Horikawa et al. (2009). Thus, the store has been intensified its management foundation with information technology.

As the preceding researches, we introduce cases of decision making support for farmers in the store. Hanzawa et al. (2007) developed an information system for fresh agricultural product. The system grasps sales and stock information, and sends it by e-mail to the farmer's cellular phone. Ma et al. (2009) proposed sales forecasting model corresponding to the characteristics of products in farmer's store. Table **1** shows the model by demand property. Kasai et al. (2009) analysed the mean shelf time and supported pricing decision at arrival stage. For example, Figure 2 portrays Average stocks staying time per (ASSTp) price for a pack of prune. It shows that a pack of prune ought to be sold at 250 yen.

Table 1 Sales forecasting model by demand property

Type	Demand Property	Sales Forecasting Model
A	· high seasonality · unsteady state	Smoothing method
B	· low seasonality · steady state or strong steady difference	Autoregressive moving average method
C	· non seasonality · unsteady state · regular assortment	Regression analysis method

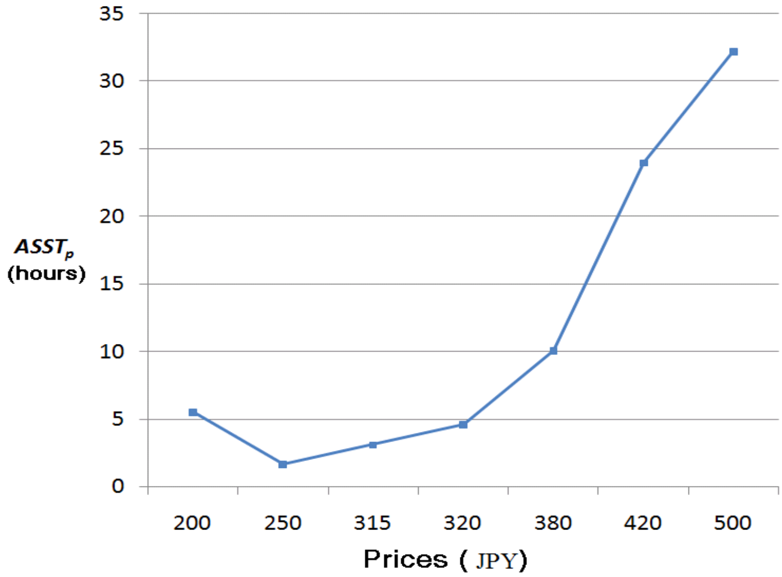


Figure 2 Average stocks staying time per price (A pack of prune)

ARRIVAL AND SALES PLANNING SUPPORT SYSTEM

In this research, we propose a structure of arrival quantity adjustment. We developed an Arrival and Sales Planning System to support sales plan making for farmers and manager.

Figure 3 portrays practical system implementation of "SANCYOKU Akasawa". The store is already operated arrival, sales, stocks, shelf location and sales promotion management systems by the preceding researches. The proposed system utilizes these preceding systems. Figure 4 portrays Business flow diagram in the store after the system will be implemented.

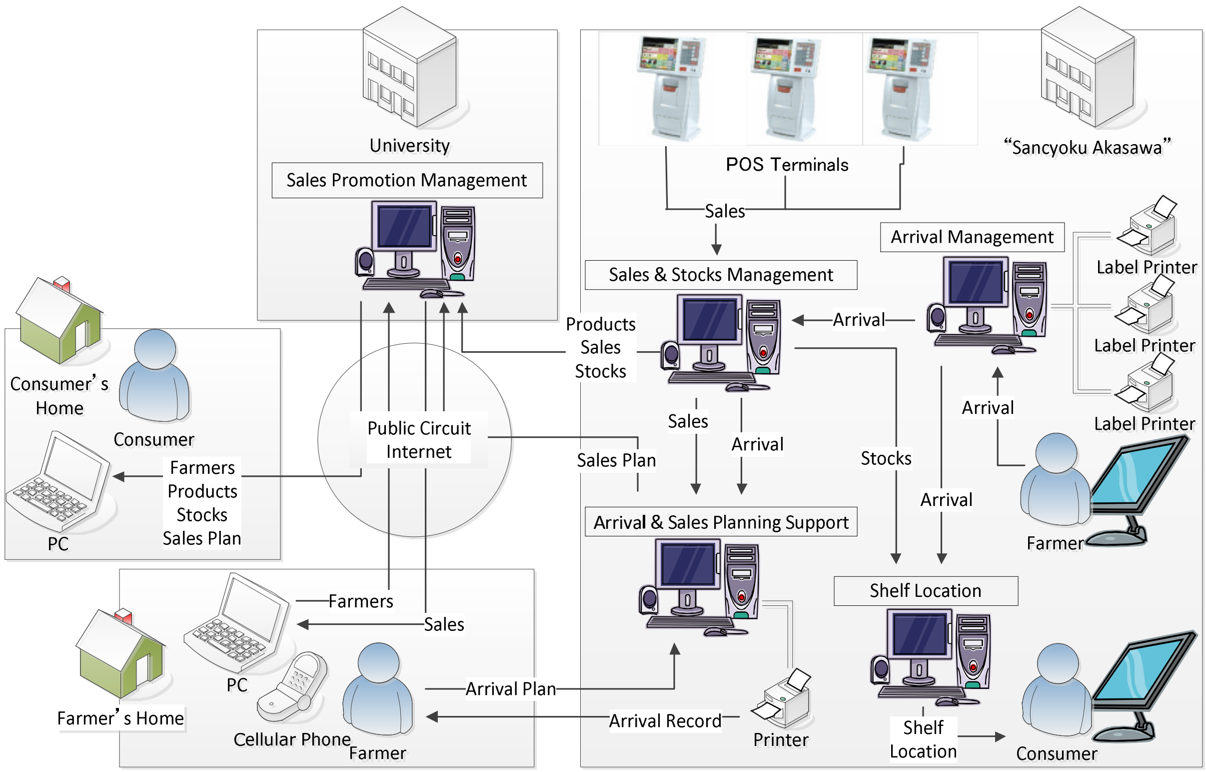


Figure 3 Practical system implementation of "SANCYOKU Akasawa"

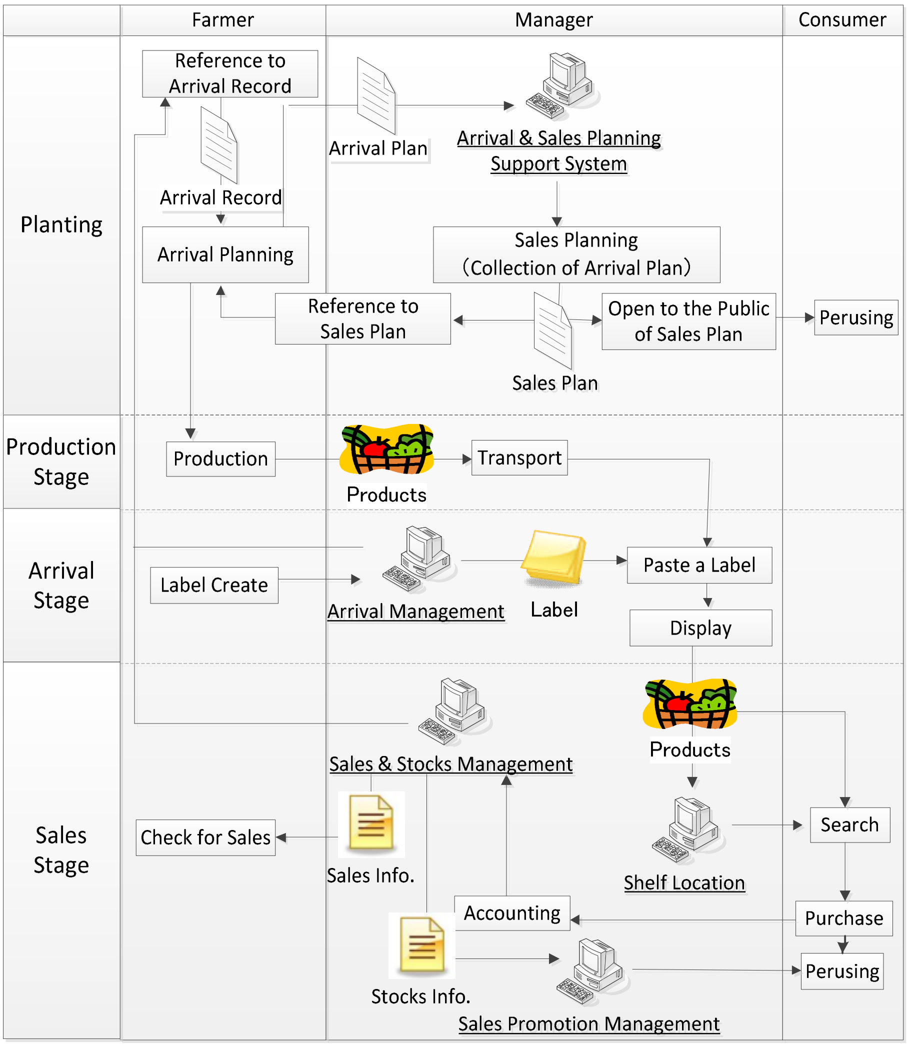


Figure 4 Business flow diagram (after implemented the system)

The proposed system provides following two functions: 1) arrival plan making by the farmers and 2) sales plan making based on the arrival planning.

1) Arrival Plan Making by the farmers
Each farmer makes an annual arrival plan by referring to the previous statistics. The value of arrival plan shows as below.

- Product name
- Unit of product
- Monthly arrival quantity
- The highest and the lowest selling prices

Farmers review and revise the arrival plan, when necessary, by comparing the arrival plan and actual results. At the store, there are many farmers who are not good at operating a computer terminal. Therefore, they write value of arrival plan and arrival results in the report. Initial value of arrival plan is arrival record of the previous year.

2) Sales Plan Making based on Arrival Planning.
The server collects each arrival plan of individual farmer and makes sales plan for the entire store. Then, the sales plan will be put on view on the store's website for consumers use. When farmers refer to the sales plan, they can grasp planning situations for the entire store.

IMPLEMENTED ARRIVAL AND SALES PLANNING SUPPORT SYSTEM

We have operated the system in the store since April 2009. Table 2 shows history of the implemented system. In 2009, farmers made an annual arrival plan once a year. In 2010, they made the arrival plan and reviewed this every four month.

Table 3 shows comparison of 2009 sales record and 2010 sales plan for 7 products. There is not much difference in sales period both sales plan and sales record. Thus, for the products with short sales period, sales quantity is concentrated within a given period of time, while ones with longer sales period tend to level out over the months.

Furthermore, we carried out on questionnaire survey to farmers in April, 2009. The questionnaire was retrieved 33 out of about 130 farmers. Figure 5 portrays the result to the system. As a result, we found out about 70 percent of farmers were in favor of the system.

Table 2 History of implemented system

Year / Month		Content
2009	2010	
4	3	Arrival Planning
6	5	Sales Planning
9	6	Sales Plan Opened to the Public
-	6	Revision of Arrival Plan (first)
-	10	Revision of Arrival Plan (second)

Table 3 Comparison of sales record and sales plan (2009-2010 season)

Product Name (Category)	Sales Period (month)		CV of monthly Sales Quantity	
	Record Value	Plan Value	Record Value	Plan Value
San-fuji (Apples)	7	7	1.22	1.31
Wase-fuji (Apples)	10	10	1.44	1.36
Campbell (Grapes)	5	4	2.23	2.27
Japanese ginger (Vegetables)	4	4	2.00	2.28
Pumpkin (Vegetables)	8	8	1.19	1.01
Grape juice (Juice)	12	12	0.42	0.19
Apple juice (Juice)	12	12	0.63	0.48

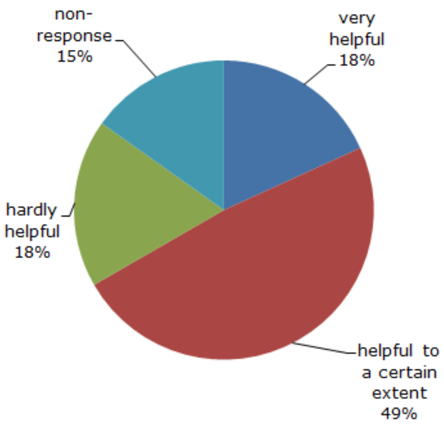


Figure 5 Result of questionnaire survey (to the system)

Secondly, we analysed sales data from the points of arrival plan making and quantity adjustment by sharing the sales plans. We define value of *Purchase Index (PI)* by month as an evaluation index, and compared *PI* in 2009 and *PI* in 2010. Definition of *PI* shows as below.

$$Purchase\ \ Index = \frac{Sales\ \ amount\ \ per\ \ month}{Number\ \ of\ \ customers\ \ per\ \ month}$$

For example, we analysed difference in *PI* values in 2010 and in 2009 when the system was installed, and also ratio of monthly sales amount (comparison of *PI* values of Purchase Index) of 7 products that were introduced on Table 3. Figure 6 portrays a case of "San-fuji", and Figure 7 portrays a case of "Grape juice".

"San-fuji", "Campbell" and "Pumpkin" showed increase of *PI* in their off-season, while "Wase-fuji", "Japanese ginger", "Grape juice" and "Apple juice" did not show characteristic changes.

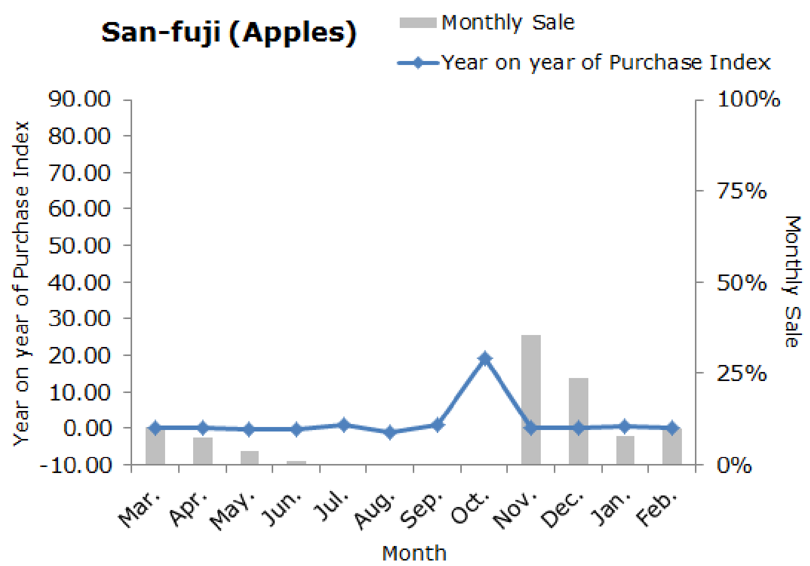


Figure 6 Monthly sales and year on year of Purchase Index (San-fuji)

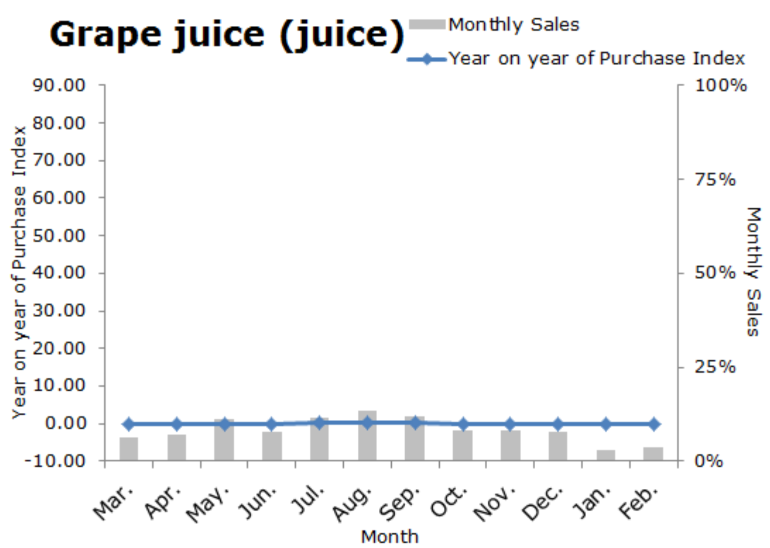


Figure 7 Monthly sales and year on year of Purchase Index (Grape juice)

Knowledge obtained by the system implementation is presented as follows.

(1) Seasonal products trend to concentrate quantity of sales plan at a specific period.
(2) Regular products trend to equalize quantity of sales plan throughout the year.
(3) An evaluation of the system is different by farmers acquiring style of usage.
(4) It is possible to say that consumer is provided more purchase occasion for seasonal products by quantity adjustment.
(5) It is possible to say that regular products are not required much quantity adjustment.

CONCLUSION

In this paper, we proposed support to farmer's decision making to satisfy consumer demands and developed the system in farmer's store. With the system, farmers can grasp of each farmer's sales strategy, and use for management strategy of the store. Moreover, the consumers can check its peak season of products by the sales plans on the web.

We have operated the system in the farmer's store. As a result, many farmers could obtain the better trend of sales for the some products the method was installed. Furthermore, the method made it possible to secure a wider selection of seasonal commodities in their off-season.

Henceforth, we are going to propose a sales planning model based on the regional market trend at farmer's store. Furthermore, we make at most efforts forwards to the management improvement applying mechanism of shipping advice that corresponds with the arrival plan.

REFERENCES

- Ose, Y., 2002, The Possibility of IT Utilization in Case of the Crop Distribution, the development finance institute report, Vol.13, pp.98-118. (in Japanese)
- Nakajima, K., 2005, Farmer's Store Support System Utilizing SEICA, Fresh-Food-System, Vol.34, No.2, pp.24-27. (in Japanese)
- Shimakawa, Y., Sugiyama, J., Nakajima, K., Takagi, J., 2008, Design of Item Barcode Utilizing Number of SEICA Catalogue, Agricultural Information Research, Vol.17, No.3, pp.111-118. (in Japanese)
- Horikawa, M., Takeno, T., Ohba, M., and Sugawara, M., 2009, Vender Managed Inventory for Farmer's Markets, Proceedings of 20th International Conference on Production Research. pp.153.
- Hanzawa, Y., Takeno, T., Horikawa, M., and Sugawara, M., 2007, Management Support System Realizing Direct Sales of Agricultural Product, Proceedings of the 12th International Symposium on Logistics, pp.396-401.
- Ma, X. Uetake, T. Horikawa, M. and Sugawara, M., 2009, Development of Sales Forecasting Model for Farmers' Markets, the 5th ICLS, pp.292-297.
- Kasai, S., Takeno, T., Horikawa, M., and Sugawara, M., 2009, Development of Inventory Management System and Analysis of Consumer's Behavior in Farmers' market, Proceeding of the 10th Asia Pacific Industrial Engineering and Management System Conference, CD-ROM.

SUSTAINABILITY STRATEGIES IN AN EPQ MODEL WITH PRICE- AND QUALITY-SENSITIVE DEMAND

Christoph H. Glock[1], Cory Searcy[2], Mohamad Y. Jaber[2]
[1] Chair of Business Management and Industrial Management, University of Würzburg, Würzburg, Germany
[2] Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada

ABSTRACT
This paper studies a manufacturer producing a single product which is sold on a market where demand is sensitive to price and quality. The production process of the manufacturer is assumed to impact the environment, for example by producing emissions or scrap or by consuming non-renewable resources. The environmental impact of the production process is treated as a quality attribute in this paper, and it is assumed that environmentally conscious customers are willing to pay a higher price for the product in case the environmental impact of the production process is reduced (or, likewise, a higher degree of sustainability is achieved). The model developed in this paper studies the trade-off between sustainability, costs and demand and proposes strategies to maximise the manufacturer's profit.

INTRODUCTION
There is a growing recognition that corporations play a critical role in achieving global sustainability (Shrivastava, 1995). Over the last two decades, individual corporations and industry associations in virtually all economic sectors have developed policies, plans, and programs to address sustainability issues. These initiatives typically focus on addressing the "triple bottom line" of corporate economic, environmental, and social performance (Elkington, 1997). One industry that has been particularly active in implementing sustainability initiatives is the manufacturing sector.

There are ongoing debates on what sustainability means in a manufacturing context. There is no universally accepted definition of sustainable manufacturing or sustainable production. However, one widely-used definition of sustainable production defines it as "creating goods by using processes and systems that are non-polluting, that conserve energy and natural resources in economically viable, safe and healthy ways for employees, communities, and consumers which are socially and creatively rewarding for all stakeholders in the short- and long-term future" (Glavic and Lukman, 2007). Although each corporation will define sustainability according to its own needs, this definition provides insight into the goals, objectives, and targets typically associated with sustainability initiatives in the manufacturing sector.

To help measure the success or failure of their sustainability initiatives, many corporations in the manufacturing sector have developed sustainability indicators. The development of sets of sustainable production indicators has also been the subject of several academic publications, including Veleva and Ellenbecker (2001), Krajnc and Glavic (2003), and Fan et al. (2010). Many other papers have explored the development of sustainability indicators for specific companies within the manufacturing sector. An extensive review of the state-of-the-art of industrial sustainability indicators was provided by Arena et al. (2009). However, while the literature shows that many meaningful contributions have been made, work remains. In particular, none of the indicators in the publications noted above have explicitly explored the link between a corporation's sustainability performance and demand for its products.

A recent systematic review of 91 articles showed that the research on consumer willingness to pay for ethically produced goods – encompassing issues such as environmental and labour practices – has yielded mixed results (Cotte and Trudel, 2009). However, the overall findings of the systematic review suggested that consumers were willing to pay a premium for sustainably-produced products. It also suggested that consumers will demand a discount for products produced in an unsustainable fashion. These findings have implications for the design of sustainability indicators. In particular, they highlight the need for indicators that address the trade-offs between sustainability, demand, costs, and profit.

The purpose of this paper is to present a mathematical model that addresses these trade-offs by studying how the production policy of a manufacturer influences demand and how the sustainability of the production process interacts with the manufacturer's pricing decision. The results of the paper are especially important for companies operating in markets where customers perceive the sustainability of a product as a quality criterion. The paper shows that by controlling price and quality (sustainability) of a product, the company can stimulate demand and increase profit, which may result in a competitive advantage.

The remainder of the paper is structured as follows: The next section introduces the model and section 3 presents numerical results. The last section concludes the paper and provides suggestions for future research.

THE MODEL

The following section considers the case of a manufacturer producing a single product that is sold on a market where demand is sensitive to both the product's price and quality. The demand function used in the paper is adopted from Banker et al. (1998) and it is of the form:

(1) $$D(p,q) = a - bp + cq$$

where p denotes the price of the product, q product quality, a the maximum demand in case quality equals zero, and b and c the elasticity of demand in price and quality, respectively. The environmental impact of the production process is treated as a quality characteristic in this paper, and it is assumed that the customers attribute a higher quality to products that have a minimal effect on the environment. To capture this attribute, we introduce a sustainability indicator SI to measure product quality, which accounts for two types of pollutants in this paper, namely emissions and scrap, and it is postulated as:

(2) $$SI = Em \cdot Sc$$

Sc denotes the level of scrap avoidance with $Sc = S_0/S(I)$, where S_0 is the minimum scrap attainable and $S(I)$ is the amount of scrap generated under investment I with $S(I) = S_0(1 + I^{-\gamma})$. It is clear that $Sc = 1/(1 + I^{-\gamma})$ with $0 < Sc \leq 1$ and that the customers prefer high levels of Sc. As can be seen, scrap is assumed to be independent of either lot size or the production time. Models that consider a lot size- or production time-dependent scrap rate are found in Lee and Rosenblatt (1987) and Jaber and Khan (2010), among others. The other term in Eq. (2) is E_m, which denotes the level of emission that can be avoided. We also assume that the emissions caused by the manufacturing process depend on the production rate P and occur according to a quadratic function of the form $E(P) = dP^2 - eP + f$, (see Bogaschewsky, 1995), where d, e and f are parameters of the emission function. Intuitively, a production rate P_0 which minimises emissions and which leads to a minimum emission level E_0 exists, with $P_0 = e/2d$ and $E_0 = f - e^2/(4d)$. It is clear that $0 < Em = E_0/E(P) \leq 1$ and that customers would prefer a value of Em close to 1. Further, it follows that $0 < SI \leq 1$.

Figure 1 illustrates the behaviour of inventory over time for the manufacturer. For a given demand rate $D(p,q(I,P))$, the inventory carrying costs can be calculated as:

(3) $IC = h\left(\frac{Q^2}{2(Q-S(I))P} + \frac{Q-S(I)}{2D(p,q(I,P))}\right)$

It is clear from Eq. (3) that the manufacturer can minimise its inventory carrying costs during the production phase by choosing to produce at maximum capacity, $P_{\max}$. Adopting a higher production rate than P_0, however, increases emissions of the production process and consequently reduces the demand rate D. This leads to higher inventory carrying costs in the consumption phase of the lot and lower revenues from sales. Producing at a rate lower than P_0 is not beneficial for the manufacturer as it will lead to higher inventory carrying costs and lower customer demand.

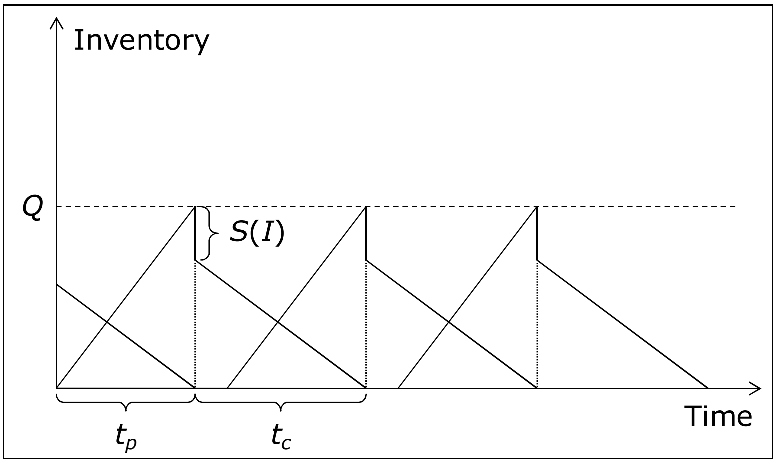


Figure 1: Inventory time plot

Apart from the inventory carrying costs, we assume that the manufacturer incurs investment and setup costs, which amount to

(4) $SC = \frac{(K+I)D(p,q(I,P))}{Q-S(I)}$

Demand per unit of time is given from Eq. (1), wherefore the sales revenue is given as $pD(p,q(I,P))$. Considering Eqs. (3) and (4), the profit of the manufacturer can be calculated as (Revenue – total costs)

(5) $\Pi(I,P,p,Q) = pD(p,q(I,P)) - h\left(\frac{Q^2}{2(Q-S(I))P} + \frac{Q-S(I)}{2D(p,q(I,P))}\right) - \frac{(K+I)D(p,q(I,P))}{Q-S(I)}$

Production costs that vary with the production rate and that may be attributed to changes in energy consumption, for example, are not considered in this paper. The reader is referred to Glock (2010, 2011) for a discussion of lot sizing-problems with variable production rates and rate-dependent production costs.

The optimisation problem of the manufacturer is to find values for Q, P, p and I that maximise the total profit given in Eq. (5). The optimal lot size that maximises Eq(5) is found by using differential calculus to be:

(6) $Q^* = S + \sqrt{\frac{D(p,q(I,P))(2D(p,q(I,P))(K+I)P + hS(I)^2)}{(D(p,q(I,P))+P)h}}$

Substituting Eq. (6) in Eq. (5) gives

(7) $\Pi(I,P,p) = pD(p,q(I,P)) - \sqrt{\frac{hD(p,q(I,P))(2D(p,q(I,P))(K+I)P + hS(I)^2)}{D(p,q(I,P))+P}}\left(\frac{1}{D(p,q(I,P))} + \frac{1}{P}\right) - \frac{h}{P}S$

Due to the complexity of Eq. (7), concavity of the objective function in the decision variables is difficult to prove. To calculate a good solution for the optimisation problem, we used the NMinimize-function of the Software-Package Mathematica 7.0 by Wolframs Research Inc., a function that contains several methods for solving constrained and unconstrained global optimisation problems, such as genetic algorithms, simulated annealing, or the Simplex method.

NUMERICAL STUDIES

To illustrate the behaviour of the model developed above, we consider the following input parameters: a = 400, b = 0.75, c = 100, d = 0.01, e = 10, f = 125000, h = 12, K = 250, $P_{\max}$ = 1000, S_0 = 10 and γ = 0.1. For this set of parameters, the optimal policy is to produce Q^* = 16961.20 units with a production rate of P^* = 579.20 units/unit of time. Further, it is optimal to invest I^* = 43016.27 to reduce the amount of scrap per lot to Sc = 13.44 units and to sell a unit of the product for P^* = 316.61. Demand per unit of time as given in Eq. (1) will be 236.90 units in this case, and the lot of size $Q - S(I)$ will be consumed after 71.54 units of time. The profit of the manufacturer for this sample data set is 73796.90 (cf. example #1 in Table 1).

To gain further insights into the behaviour of the model, we varied several of the model parameters and studied their impact on the decision variables and the profit of the manufacturer. The results are summarised in Table 1.

Table 1: Sample data sets used for numerical experimentation

#	c	b	e	f	h	S_0	γ
1	100	0.75	10	125000	12	10	0.1
2	50	0.75	10	125000	12	10	0.1
3	10	0.75	10	125000	12	10	0.1
4	0	0.75	10	125000	12	10	0.1
5	150	0.75	10	125000	12	10	0.1
6	200	0.75	10	125000	12	10	0.1
7	100	0.50	10	125000	12	10	0.1
8	100	0.25	10	125000	12	10	0.1
9	100	1.00	10	125000	12	10	0.1
10	100	1.25	10	125000	12	10	0.1
11	100	0.75	12	125000	12	10	0.1
12	100	0.75	14	125000	12	10	0.1
13	100	0.75	16	125000	12	10	0.1
14	100	0.75	10	75000	12	10	0.1
15	100	0.75	10	25000	12	10	0.1
16	100	0.75	10	5000	12	10	0.1
17	100	0.75	10	125000	6	10	0.1
18	100	0.75	10	125000	1	10	0.1
19	100	0.75	10	125000	18	10	0.1
20	100	0.75	10	125000	24	10	0.1
21	100	0.75	10	125000	12	100	0.1
22	100	0.75	10	125000	12	1000	0.1
23	100	0.75	10	125000	12	10	0.5
24	100	0.75	10	125000	12	10	1.0
25	100	0.75	10	125000	12	10	2.0

It is clear from Table 1 that a variation in the parameter c impacts product quality, which subsequently influences demand. If c is reduced, customers would be less interested in the sustainability of the manufacturer's production process and attribute a relatively higher importance to the price of the product. Consequently, the manufacturer has a lower incentive to produce with a low level of emissions and scrap, wherefore it increases the production rate and reduces the investment level to lower inventory and investment costs (cf. examples #1 to #4). Simultaneously, since the product price becomes the major criterion in the purchasing decision of the customers, the manufacturer reacts by reducing the product price to attract further buyers and to compensate for the loss of quality-oriented customers. Although this dampens the decline in demand somewhat, overall customer demand is reduced and the manufacturer's profit declines. In contrast, if the value of c increases, the importance of product quality increases. This entices the manufacturer to produce at a lower production rate and to invest in the production process to reduce the amount of units that need to be scrapped (cf. examples #5 and #6).

Similarly, parameter b influences the impact of product price on the customer demand for the product. Consequently, customers are more sensitive to product price for higher values of b than for lower values, which leads to a high product price for low values of b and vice versa (cf. examples #7 to #10). Further, it can be seen that for lower values of b, the manufacturer tries to attract further customers by increasing product quality, while in the case of highly price-sensitive demand, product quality is reduced. Obviously, there is an interaction between price and product quality: if price has to be reduced, the manufacturer tries to stimulate demand by increasing product quality, and vice versa.

Table 2: Results of the numerical study

#	Q	P	I	p	$S(I)$	q	$D(p,q)$	t_c	Π
1	16961.2	579.20	43016.3	316.61	13.44	0.74	236.90	71.60	73796.9
2	7978.9	583.11	10774.0	290.73	13.95	0.72	217.77	36.64	62709.4
3	2172.4	618.44	648.0	271.09	15.23	0.66	203.24	10.69	54926.6
4	1201.4	1000	0.1	266.68	22.70	0.43	199.99	6.01	53248.2
5	27790.6	578.40	101288.0	343.19	13.16	0.76	256.55	108.33	86168.6
6	40600.7	578.49	190801.0	370.22	12.96	0.77	276.52	146.83	99771.8
7	24517.7	575.62	89909.6	476.28	13.20	0.76	237.60	103.19	111418.6
8	45971.6	569.90	315257.0	956.97	12.82	0.78	238.74	192.56	225183.3
9	13067.3	581.92	25478.5	236.96	13.63	0.73	236.39	55.28	55083.1
10	10685.5	584.17	16976.9	189.30	13.78	0.73	235.98	45.28	43898.3
11	17579.7	662.15	44519.8	316.63	13.43	0.74	236.97	74.19	73823.8
12	18116.7	749.41	45821.3	316.64	13.42	0.75	237.02	76.43	73845.4
13	18580.5	839.81	46942.7	316.65	13.41	0.75	237.07	78.38	73862.8
14	16726.3	551.07	42453.7	316.62	13.45	0.74	236.89	70.61	73791.5
15	16424.5	517.64	41731.2	316.62	13.45	0.74	236.87	69.34	73785.1
16	16274.7	502.07	41372.6	316.63	13.45	0.74	236.86	68.71	73782.0
17	32860.5	576.11	80788.5	317.39	13.23	0.76	237.50	138.36	74209.6
18	181327.8	568.74	408559.1	319.28	12.75	0.78	238.96	758.82	75217.2
19	11525.0	581.13	29740.5	316.15	13.57	0.74	236.54	48.72	73549.2
20	8765.3	582.56	22889.5	315.81	13.66	0.73	236.28	37.10	73370.5
21	17091.4	580.13	43042.5	316.61	134.40	0.74	236.90	72.14	73794.3
22	18420.2	589.51	43373.1	316.61	1343.78	0.74	236.91	77.75	73768.4
23	6399.0	525.97	5561.08	332.59	10.13	0.99	249.22	25.68	82437.4
24	2392.5	510.20	562.61	333.27	10.02	0.99	249.87	9.58	83103.2
25	1512.4	506.54	73.71	333.36	10.00	0.99	249.96	6.05	83219.1

In the next step of our analysis, we increased the parameter e, which represents the technical characteristics of the production process and which influences the impact a variation in the production rate has on the emissions caused when producing the product. An increase in e reduces the slope of the emission function and consequently the impact a variation in P has on the emissions caused in the production process. Since an increase in e further leads to a higher emission-minimal production rate P_0, P is increased as e takes on higher values (cf. examples #11 to #13). However, the relative derivation of P from P_0 is less for higher values of P_0. This leads to higher product quality, higher customer demand and higher profits for the manufacturer. This illustrates that in case a manufacturer faces quality-sensitive customer demand, it has an incentive to invest in new technology to improve the characteristics of the production process and to be able to achieve higher product quality for a given set of process parameters. A reduction in the parameter f, in turn, leads to a lower level of emissions per unit produced for a given production rate P. Although this is favourable from the perspective of the environment, the manufacturer now faces the problem that a variation in P leads to a relatively higher increase in emissions since the initial level of emission is lower. As a consequence, the manufacturer has to reduce P as f takes on lower values, which reduces profit. Thus, it is not beneficial from the manufacturer's perspective to reduce the parameter f and therewith the overall level of emissions caused in the production process, especially since a reduction in f would be associated with a cost in many practical situations. This is due to the fact that the decision criterion used by the customers in this paper only considers changes in emissions, but not the overall level of emission caused, which gives wrong incentives to the manufacturer (as seen from an environmental perspective).

Examples #17 to #20 illustrate the effect of a variation in inventory carrying charges on the production policy of the manufacturer. It can be seen that a decrease in h reduces the importance of inventory carrying costs in the model, which leads to a larger lot size and a lower production rate P. This, in turn, increases product quality and customer demand and enables the manufacturer to charge a higher price from the customers. The profit of the manufacturer consequently increases if h is reduced and vice versa.

If the minimum scrap attainable in the production process increases, the manufacturer decides to increase the investment I to bring the actual level of scrap generated by the manufacturing process closer to an acceptable level. Further, the lot size is increased to reduce the overall amount of scrap generated in the production process. Finally, a reduction in the level of scrap avoidance Sc is balanced by an increase in the production rate P, which helps the manufacturer to reduce inventory carrying costs. The profit of the manufacturer is reduced as the minimal possible level of scrap increases (cf. examples #21 to #22).

A variation in the parameter γ finally influences the impact the investment of the manufacturer has on the amount of scrap generated in the production process. For high values of γ, a relatively small investment is necessary to bring the level of scrap close to the minimal level S_0, while for a low value of γ, a large investment is possible. As can be seen in examples #23 to #25, the manufacturer decides to reduce the level of scrap as γ increases. Further, since a low level of scrap avoidance Sc stimulates the impact of a variation in P on product quality due to the multiplicative correlation of Em and Sc in Eq. (2), the manufacturer simultaneously reduces the production rate to lower emissions. This, in turn, leads to high product quality, high customer demand and an increase in the manufacturer's profit.

CONCLUSION

This paper studied a manufacturer producing a single product which is sold on a market with price- and quality-sensitive demand. The production process of the manufacturer was assumed to produce emissions and to generate scrap, and it was also assumed that the manufacturer can control both emissions and scrap by varying the production rate or by investing in the production process. It was shown that by controlling scrap and emissions, the manufacturer can attract additional customers and increase its profit, which may result in the manufacturer having a competitive advantage over its competitors. The results indicate that the decision criterion used by the customers to evaluate products determines the behaviour of the manufacturer. If customers only value changes in the level of sustainability, as was assumed in the paper, the manufacturer will solely concentrate on the variation in emissions and scrap, which is maximised in case it wants to attract further customers or minimised in case it tries to conceal lower overall levels of sustainability. In fact, if customers only value changes in the level of sustainability, the manufacturer has no incentive to reduce the overall levels of scrap and emissions, which would increase the negative impact of changes in the production rate and would make higher investment levels necessary. This illustrates that more sophisticated decision criteria (or incentive systems) are necessary if customers want to give manufacturers an incentive to increase the sustainability of their production processes.

Future research could focus on studying the impact of alternative decision criteria on the behaviour of the manufacturer to identify market conditions under which the manufacturer also reduces the levels of emissions and scrap. In addition, it would be interesting to include further manufacturers into the model that compete on price and quality. This would permit analysing how sustainability and pricing strategies of one manufacturer impact the behaviour of other competitors in the market as everyone will compete to increase its market share.

ACKNOWLEDGEMENT
The first author wishes to thank the in-kind support provided to him, as a visiting researcher, by Ryerson University, Toronto, Canada, and the Natural Science and Engineering Research Council (NSERC) of Canada for their partial financial support. This work was further supported by a fellowship within the Postdoc-Programme of the German Academic Exchange Service (DAAD). The second author thanks NSERC for their financial support. The third author thanks NSERC and the Social Sciences and Humanities Research Council (SSHRC) of Canada-Canadian Environmental Issues, for their financial support.

REFERENCES
Arena, M.; Ciceri, N.D.; Terzi, S.; Bengo, I.; Azzone, G.; Garetti, M. (2009): A State-of-the-Art of Industrial Sustainability: Definitions, Tools and Metrics. International Journal of Product Lifecycle Management, 4 (1/2/3), 207-251.
Banker, R.D.; Khosla, I.; Sinha, K.K. (1998): Quality and Competition. Management Science, 44 (9), 1179-1192.
Bogaschewsky, R.W. (1995): Natürliche Umwelt und Produktion – Interdependenzen und betriebliche Anpassungsstrategien, Wiesbaden: Gabler.
Cotte, J.; Trudel, R. (2009): Socially Conscious Consumerism: A Systematic Review of the Body of Knowledge. Network for Business Sustainability, Available online: http://www.nbs.net/wp-content/uploads/NBS_Consumerism_SR_Researcher.pdf
Accessed: February 15, 2011.
Elkington, J. (1997): Cannibals with Forks: The Triple Bottom Line of 21st Century Business. New Society Publishers, Gabriola Island, British Columbia, Canada.
Fan, C.; Carrell, J.D.; Zhang, H-C. (2010): An Investigation of Indicators for Measuring Sustainable Manufacturing. 2010 IEEE International Symposium on Sustainable Systems and Technology, Arlington, May 2010
Glavic, P.; Lukman, R. (2007): Review of Sustainability Terms and their Definitions. Journal of Cleaner Production, 15 (18), 1875-1885.
Glock, C.H. (2010): Batch sizing with controllable production rates. International Journal of Production Research, 48 (20), 5925-5942.
Glock, C.H. (2011): Batch sizing with controllable production rates in a multi-stage production system. International Journal of Production Research, DOI: 10.1080/00207543.2010.528058.
Jaber, M.Y.; Khan, M. (2010): Managing yield by lot splitting in a serial production line with learning, rework and scrap. International Journal of Production Economics, 124 (1), 32-39.
Krajnc, D.; Glavic, P. (2003): Indicators of Sustainable Production. Clean Technologies and Environmental Policy, 5, 279-288.
Lee, H.L.; Rosenblatt, M.J. (1987): Simultaneous determination of production cycle and inspection schedules in a production system. Management Science, 33 (9), 1125-1136.
Shrivastava. P. (1995): The Role of Corporations in Achieving Ecological Sustainability. Academy of Management Review, 20 (4), 936-960.
Veleva, V.; Ellenbecker, M. (2001): Indicators of Sustainable Production: Framework and Methodology, Journal of Cleaner Production 9 (6), 519-549.

EXTENDED VMI IN A DEMAND-SUPPLY NETWORK AMONG A SALES NETWORK, A MANUFACTURER AND A SUBCONTRACTOR NETWORK

Erno Salmela (Correspondence) and Ari Happonen
Lappeenranta University of Technology, Skinnarilankatu 34, Lappeenranta, Finland
erno.salmela@lut.fi, ari.happonen@lut.fi

ABSTRACT
This paper examines the Extended VMI model on a three-level demand-supply network in circumstances of uncertain demand. The studied demand-supply network consists of a sales network, a manufacturer company as a hub company and a subcontractor network. With the help of the Extended VMI model, the supply network gains visibility to the aggregated demand of the sales network offices. In this way it is possible for the supply network to operate more cost-efficiently and with a better response. The most concrete benefit for the supply network is the considerable growth of manufacturing batch sizes. In addition, in the new model the goal is to optimize the whole system with the help of collaborative tactical decision-making. Until now tactical decisions concerning inventory steering parameters have mainly been made in individual companies, which has inevitably lead to suboptimization. This paper presents the features of the Extended VMI model created for the studied demand-supply network.

Keywords: VMI, extended VMI, vendor managed inventory, collaboration, company network optimization, information transparency

1. INTRODUCTION
The basic idea of the Vendor Managed Inventory model (VMI) is transferring the inventory management responsibility from the customer to the supplier (e.g. Dong et al., 2007; Holweg et al., 2005). The supplier can, for example, make decisions on quantity and timing of replenishment (Rusdiansyah and Tsao, 2005). By applying the VMI model, supply chain costs have been reduced and the service level improved simultaneously (Hoover et al., 2001). According to Danese (2006), the VMI model has traditionally been applied and studied in operations between two companies. This has led to wasting opportunities that could instead be exploited by managing the supply network as a whole rather than as a series of dyads. Each supplier-customer dyad optimizes its processes without taking the impact on the other supply network members into account. As a consequence, the implementation of the traditional VMI allows only a partial optimization of the network. In fact, she mentions that the VMI model should be applied in a more integrated manner in the network and uses the concept *Extended VMI* when applying VMI in this kind of a more extensive operational environment.

Our research aims at producing further information for the Extended VMI moldel, which has been studied little, by examining the application of the model in the three-level demand-supply network, which consists of a sales network, a manufacturer as a hub company and a subcontractor network. The studied products are electrical components, for which subcontractors supply plastic and metal subassemblies and parts.

The structure of this article proceeds so that the next chapter presents the methodology of the performed study, after which chapter 3 focuses on the VMI and Extended VMI models based on earlier scientific literature. Chapter 4 describes the current state of the operations of the studied demand-supply network and recognized problem areas in it. Chapter 5 presents the Extended VMI model as a solution to the found problems and the conclusions finishes the paper.

2. METHODOLOGY
This study was conducted as a qualitative research of one network case and it included four main stages. *In the first stage*, face-to-face theme interviews were performed. The goal of these interviews was to form a picture of the characteristics, operational models

and problems of the current state of the studied demand-supply network. People from four different organization levels participated in the interviews from the manufacturing company – business unit manager, production manager, buyer, and sales manager. Furthermore, representatives from three subcontractor companies were interviewed, which was sufficient to form an overall picture of the operations of the subcontractor network, since the manufacturer operates largely with similar practices with different subcontractors. People from the sales offices were not interviewed, since a good knowledge of the operations of the sales network was gained through the sales manager of the manufacturing company. *In the second stage* of the study, a literature review was performed in which the goal was to clarify generic operational principles of the VMI and Extended VMI models and how these models have been applied in practice and what advantages have been gained by applying them. *In the third stage*, the researchers planned a new Extended VMI model proposal to the studied demand-supply network on the basis of the information gained from the first and second research stages. *In the fourth stage*, the Extended VMI model proposal was tested with corporate representatives and the proposed model was updated on the basis of the received feedback. As a result, this paper presents the Extended VMI model as a new potential operational model for the studied demand-supply network. Practical functionality of the model is not evaluated in this paper, since at the time of writing the model had not yet been implemented. On the basis of feedback from practical operators, implementation of the model in the near future was, however, considered realistic.

3. VMI AND EXTENDED VMI

The VMI operations model is a coordination initiative whose goal is to optimize operations by synchronizing inventory and delivery decisions (Cetinkaya and Lee, 2000). Simatupang and Sridharan (2005) mention that sharing decision-making rights among partners is an essential part of VMI operations. According to them, benefits are gained when the supplier is given decision-making responsibility in integrating demand and supply. Kaipia et al. (2002) mention that processes between a supplier and a customer can be optimized better as a result of decision-making powers granted to the supplier.

In the VMI model, the supplier decides on delivery quantities and delivery timings of material on the basis of inventory level as well as sales forecast information received from the customer (Waller et al., 1999). Danese (2006) as well as Gröning and Holma (2007) have wider views of the VMI model, since according to them a supplier can also make *tactical decisions* in the VMI model on behalf of the customer; for instance decide inventory steering parameters (e.g. minimum/maximum levels) on the basis of the customer's service level and cost targets. Marqués et al. (2010) mention that the more dynamic steering parameters are, the better is the performance. Hines et al. (2000) attach *strategic collaboration* viewpoint to the VMI model, as well, by defining the VMI as a collaborative strategy between a customer and a supplier to optimize the availability of products at minimal cost to the two companies. Also Marqués et al. (2010) have highlighted the collaboration viewpoint: VMI is a replenishment pull system where the supplier is responsible for the customer's inventory replenishment, inside a collaborative pre-established medium/long-term scope.

Information exchange is a basic requirement for the success of the VMI model (Hoover et al., 2001). In the VMI model the customer shares inventory information with the supplier instead of making ordering decisions (Disney and Towill, 2002). According to Min et al. (2005), shared information improves decision-making in the supply chains. With the help of shared demand information, the supplier can respond to demand volatility proactively instead of reactively (Claassen et al., 2008). Instead, absence of visibility into demand leads to poor decisions – especially in context with change/exceptional situations (Galasso et al., 2009). Kaipia et al. (2002) mention that transparent inventory information gives the supplier more time to respond to the demand. Hoover et al. (2001) mention that the supplier can utilize the gained time advantage in better planning of the supplier's operations which leads simultaneously to an improvement in the customer's service level and a decrease in the supply chain costs.

According to Danese (2006), the above-presented "traditional" VMI model results in suboptimized operations in the supply chains/networks. She has studied the *Extended VMI model*, in which the focus is more widely on companies of the supply chain/network instead of two companies – either vertically in the supply chains by examining several levels or horizontally on a company network level. Synchronized Supply (SS) defined by Holveg et al. (2005) seems to be very close to the concept of the Extended VMI. With the SS they mean operations between companies in which collaboration is performed in both planning and inventory operations. According to them, a supplier makes planning decisions in addition to replenishment decisions in the SS – for instance plans production batches. In addition, in the SS the supplier takes inventory level information received from different customers into consideration in the planning. However, they do not consider an extended vertical chain like Danese. Also Elvander et al. (2007) have separated fragmented demand and overall demand of the customer chain when viewing horizontal VMI operations.

Our research is mainly based on the above-presented Danese's (2006) viewpoint of the Extended VMI model, but there is one small difference in the inspection. In our study, the vertical viewpoint of the model is the same as with Danese, meaning that the VMI model is applied in more than two levels of the chain. Instead the horizontal viewpoint differs, since with the horizontal Extended VMI model Danese refers to communication between companies on the same chain level; for instance, if one supplier is late with deliveries to a customer, other suppliers can also delay their own deliveries to the same customer when receiving information of this. We approach the horizontal model from the viewpoint of aggregating inventory information received from the horizontal sales network (cf. Elvander et al., 2007) and utilizing this information in optimizing the operations of the supply network.

4. CURRENT STATE OF THE STUDIED DEMAND-SUPPLY NETWORK

The studied participants and their core operations are presented in Figure 1. The manufacturer and subcontractors are situated in Finland, whereas the sales network is global. The sales offices belong to the same corporation as the manufacturing company.

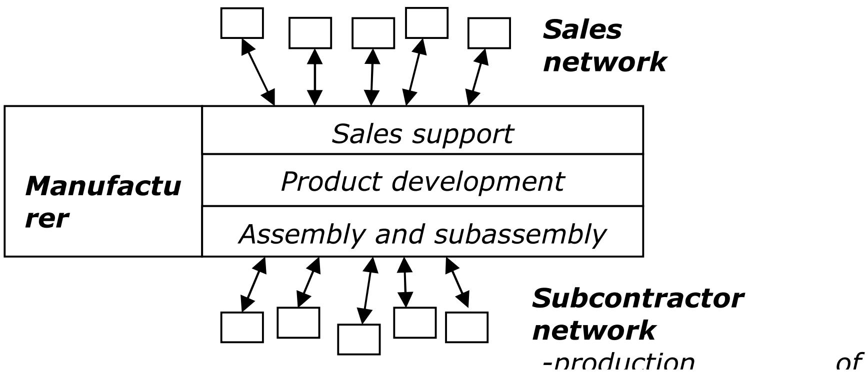


Figure 1. The studied three-level demand-supply network.

The manufacturer focuses on assembling electrical products from subassemblies and parts supplied by subcontractors. Manufacturing volumes are very large, since few millions of products are sold on an annual level. Overall demand is quite steady on a product group level, so on this level demand is quite easy to forecast. Making product-specific forecasts is, however, very difficult except for individual high volume products. Unit prices of the products are low, ranging from a few tens of cents to tens of euros.

Demand-supply operations in the present situation

Sale of the products to the customers happens through tens of sales organizations. Customer demand can be seen as request for offers and orders in the sales offices. Sales offices interact with the centralized sales support situated in the manufacturer's facility concerning forecasts and ordering. Each sales office forecasts the demand of its own market area, after which centralized sales support bundles the forecasts together. In addition to forecasts received from the sales offices, the centralized sales support utilizes history information of earlier orders of the sales network when making an overall forecast. Overall forecasts are automatically broken down into subcontractor-specific material requirements. In addition to the forecasts from the sales offices, demand is visible to the manufacturer as orders. Sales offices keep their own inventories of products with the greatest demand. Orders to the manufacturer are based on the existing inventory level in addition to their forecast. In the present situation, the sales offices define independently the products to be inventoried as well as their inventory steering principles and parameters (quantity of storage buffers, order point, replenishment batch size and delivery time). Products to be buffered and especially the levels of the buffer stocks vary greatly among the sales offices. At present, the manufacturer does not have visibility to these inventory levels. Thus, the VMI model is not used.

The manufacturer's orders on hand is very short (at the time of this research about two weeks), which has lead to very hectic operations in the supply network. Orders from the sales offices launch an assembly, meaning that the assembly is not planned at all. Planning the manufacture of subassemblies is minor, too. Due to fast delivery time requirements of the sales offices, subcontractors have only a couple of days of delivery time towards the manufacturer, so the subcontractors must, in practice, respond to the orders from the outbound inventory. The manufacturer keeps small inbound inventories (few days of supply) for the subcontractor items. In these inventories falling under the order point leads to call-offs for the subcontractors. This is not a case of the VMI model, since the manufacturer makes all decisions related to steering parameters (e.g. min-max limits of subcontractor, order points and replenishment batches). The manufacturing batch size of the subcontractors is usually multifold compared to the delivery batch size. The make-to-stock strategy (MTS) is a competitive factor for the subcontractors, since large batch sizes enable cost-efficient operations. On the other hand, in the MTS model there is also an underlying risk of products being left on the shelf, especially if product updates are not received early enough from the manufacturer.

Problems at the current state

Manufacturing batch sizes of the manufacturer are very small, which causes cost-inefficiency in the operation due to high setup and handling costs. The reason for the small batch sizes is that sales network demand is seen as small fragments towards the supply network - a couple hundred thousand order lines come from the sales network annually. The assembly batches correspond in size with the batch sizes of the order lines from one sales office. In consequence, the average assembly batch size is less than 10 pieces. The most high volume subassemblies are manufactured with MTS, but subassemblies of smaller volume are manufactured with the Make-to-order (MTO) strategy. In addition to the batch sizes of the manufacturer, the manufacturing batch sizes of the subcontractors could be optimized as well, although not as much as the manufacturer's. In the supply network, the inaccuracy of the forecasts makes the MTS manufacturing of the subassemblies and parts difficult, which results in cost-inefficiency and poor supply reliability towards the sales offices.

In the present situation, the forecasts are too unreliable and, on the other hand, the orders distort demand (the bullwhip effect) in the studied demand-supply network. In practice, the supply network does not know what happens to demand between a forecast and an order, so the future demand is difficult to predict. The aim was to solve these identified problems with the Extended VMI model, with which fragmented demand (replenishment requirements and advance information related to them) could be aggregated in order to make the operations of the supply network more efficient and to improve the service level.

5. THE EXTENDED VMI MODEL IN THE STUDIED DEMAND-SUPPLY NETWORK

In the Extended VMI model created for the research case, *the first important matter* is building visibility to the consumption of the inventory of the sales network. Demand information received from the inventory is situated, with regard to timing and reliability, in the middle between forecasts and orders received from the sales offices (Figure 2).

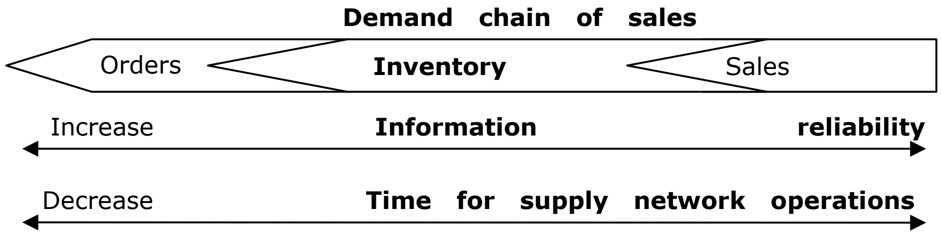


Figure 2. Sales offices´ demand information types, reliability and time benefit.

Another essential matter in the new operational model is aggregating the inventory information received from different sales offices on one hand product-specifically and, on the other hand, subassembly-specifically. *Third important matter* is deriving material requirements from the aggregated inventory information and sharing this information with the manufacturer and subcontractors. Concerning subassemblies, it is important to aggregate the requirement information of different end products, since the same subassemblies can be used in different end products of the manufacturer. Finally *the essential fourth matter* is tactical collaboration concerning dynamic setting of steering parameters. On the basis of the previous, the Extended VMI model is foremost based on effective management of information. In order to function effectively the model calls for a centralized ICT solution, since the studied demand-supply network includes dozens of different organizations and the handled information quantities are large. This corresponds with Danese's (2006) view of the necessity of a centralized ICT solution in the Extended VMI operations. The most important information flows and supply decisions of the new Extended VMI model have been presented in Figure 3.

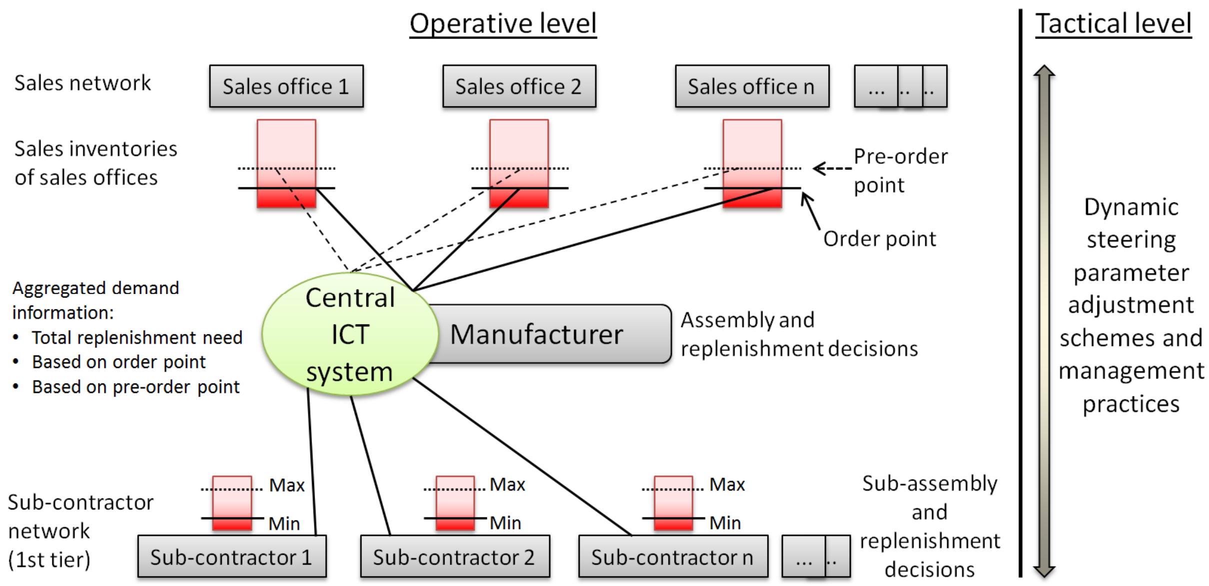


Figure 3. The Extended VMI model for the studied demand-supply network.

Next we will consider the characteristics of the new operational model on a more detailed level with regard to operations in the operative and the tactical level.

Operative level operations

Demand information received from the inventories of the sales offices can be divided into two groups – replenishment requirements and advance information of replenishment requirements. *Replenishment requirements* are based on order points and replenishment batch sizes of the sales office inventories. The system aggregates replenishment requirements product-specifically from all sales offices every day based on agreed delivery batch sizes when falling under the order point. Aggregated replenishment requirement of the sales offices launches one product-specific assembly batch with the manufacturer as well as subassembly deliveries required for this batch from subcontractors. With this model, the manufacturer can grow manufacturing batch sizes considerably compared to the present situation. Subassemblies are in storage readiness with both the manufacturer and the subcontractors*. Furthermore,* the Extended VMI model produces *advance information of the replenishment requirements* (pre-order point in Figure 3) for the manufacturer and subcontractors especially for production planning of subassembly batches. In this situation, the inventory level information of sales offices is utilized before falling under the order points. Figure 4 illustrates a situation in which manufacturing is controlled on the basis of the advance information of the replenishment requirements. When the days of supply is short in the storages of the sales offices, no other decisions can be made on the basis of advance received from the inventory. For instance, acquisition and production times of parts are too long to utilize the advance information in acquisition and production decisions. At the same time, economical manufacturing batch sizes influence the matter, as well. Therefore, the significance of the forecasts can be decreased with the help of the advance information of the replenishment requirements, but it does not replace them completely.

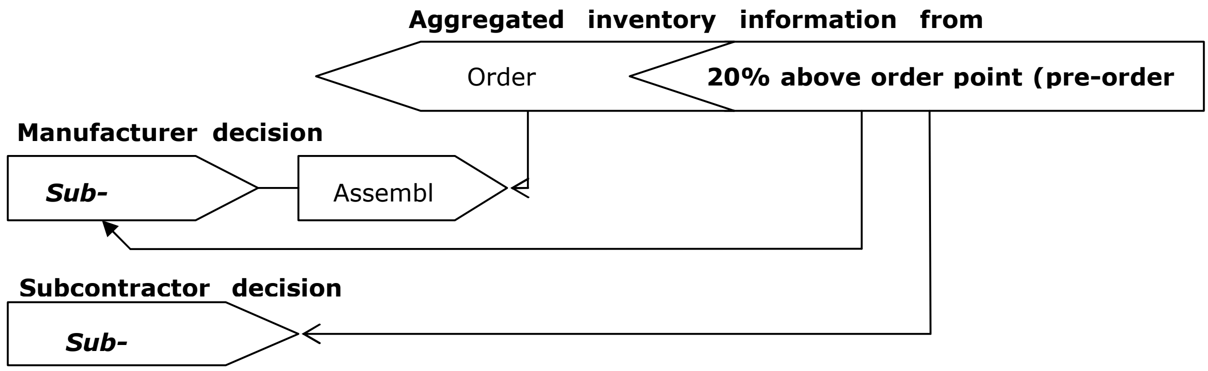


Figure 4. Replenishment and advance replenishment information from sales network.

In the figure, the value "20% above order point" presented is an example for depicting the model - not a general optimal pre-order point for the studied case. When setting the percentage, the relation of the lead time of supplying subassemblies to the consumption speed of the inventory must be taken into consideration. In practical operations, the percentage is set by analysing the fluctuation of the demand speed of the product on the basis of the product's demand history. Furthermore, the percentage is changed dynamically on the basis of changes in demand. This corresponds with the view of Marqués et al. (2010) of the usability of dynamic parameters in the VMI model.

Tactical level operations

Tactical level decisions are especially related to what products are reasonable to be stored in sales offices and setting the inventory steering parameters. The above-presented practice (Figure 4) of dynamic setting of the percentage limit of receiving advance information is one good example of a tactical level decision. In the present situation, sales offices are in charge of tactical inventory decisions, but in the future the manufacturer will want to take part either in supporting decisions of the sales offices or even in making decisions. This is possible through the new operational model, as the inventory level information is visible to the manufacturer. By analysing demand history, the manufacturer can produce information of demand profiles (seasonality and cyclicality of demand) for the sales offices. In consequence, the values of the steering parameters can be defined so that they correspond with the fluctuations of demand. Also optimal delivery times and batches can be evaluated in collaboration. Thus, the sales offices and the manufacturer manage the inventory collaboratively; the manufacturer focuses more on analysing demand history whereas the sales offices focus more on identifying changes in the future demand. In addition, the manufacturer can offer sales offices tools for making forecasts or even a complete inventory management system from the centralized ICT system over the Internet. Dynamic adjustment of the steering parameters is also extended to the operations of the subcontractors by adapting the steering parameters of their outbound inventories in accordance with changes in demand.

The most important characteristics of the developed Extended VMI Model
With the Extended VMI model it is possible to improve cost-efficiency and the service level simultaneously. In practice, this is possible to be achieved with the help of better demand information, improved planning in the supply network, and more dynamic synchronization of demand and supply. Table 1 compiles the main features of the new operational model enabling the achievement of these advantages.

1.More effective order processing routines in the whole network.
2.With the help of aggregated demand information, the assembly batch sizes of the manufacturing company will grow significantly.
3.With the help of aggregated and earlier demand information, it is possible to optimize the subassembly batch sizes.
4.Optimization of buffer stock levels to correspond with demand in the whole network with dynamic adjustment of the steering parameters done in collaboration.
5.ICT savings as a result of the centralized system. In addition, forecast tools and even an inventory management system can be offered to the sales offices.
6.Optimization of operations on the basis of identified the cyclicality of demand. For example, preparing for demand peaks by producing subassemblies beforehand.

Table 1. The main features of the Extended VMI model in the studied network.

6. CONCLUSIONS
This paper presented an Extended VMI model in the demand-supply network, which consists of a sales network, a manufacturer of electrical components and a subcontractor network. The aim was solving two problems with the model: (1) unreliable forecasting of demand has caused difficulties for the supply network to respond effectively to demand, and (2) treating the demand as fragmented in the supply network has lead to non-optimal production batch sizes. With the help of the Extended VMI model, the supply network would gain visibility to the overall replenishment requirements of the sales network as well as advance information of the replenishment requirements (pre-order points), which is more reliable than forecasts. In this way, it is possible to considerably improve both cost-efficiency and the service level. In addition, the new model is useful for the operations of the tactical level. In the present situation, tactical decisions are made independently in different organizations, which has led to suboptimal operations. In the new model, the parties make these decisions collaboratively in order to synchronize demand and supply cost-efficiently.

The presented Extended VMI model cannot be generalized on account of just one study case, but hopefully it will arouse scientific discussion on the topic in the future. In addition, the presented model had not yet been implemented at the time of writing this paper, which is why practical advantages and challenges were not yet specifically known. However, the practitioners stated that the planned model is realistic, so the advantages have already been identified. In addition it became clear that a traditional VMI model, which would be built separately towards individual sales offices, will not be even considered. In the further study, the aim is either to simulate the new model to support the implementation decision or estimate the realized benefits and problems of the already implemented model.

This study examined the Extended VMI model both on a horizontal and a vertical level. The horizontal viewpoint was studied from the aspect of aggregating demand information from the sales network and, thus, optimizing the operations of the supply network, which differs from the view of the original presenter (Danese, 2006) of the Extended VMI model, but corresponds with the view of Elvander et al. (2007). According to Danese, in the model horizontality means communication between companies that are on the same horizontal level. Furthermore, the Extended VMI was handled in this study from the viewpoint of different kinds of operative and tactical decisions in the supply network. According to Holweg et al. (2005) suppliers do not usually utilise demand information into their planning decisions, but VMI is still primarily connected to delivery decisions.

REFERENCES

Cetinkaya, S. and Lee, C.-Y. 2000, Stock Replenishment and Shipment Scheduling for Vendor-Managed Inventory Systems, *Management Science*, Vol. 46, No. 2, pp. 217-232.

Claassen, M.J.T., Van Weele, A.J., and Van Raaij, E.M., 2008. Performance outcomes and success factors of vendor managed inventory (VMI). *Supply Chain Management: An International Journal*, Vol. 13, No. 6, pp. 406-414.

Danese, P. 2006, The extended VMI for coordinating the whole supply network, *Journal of Manufacturing Technology Management*, Vol. 17, No. 7, pp. 888-907.

Disney, S.M. and Towill, D.R. 2002, A discrete transfer function model to determine the dynamic stability of a vendor managed inventory supply chain, *International Journal of Production Research*, Vol. 40, No. 1, pp. 179-204.

Dong, Y., Xu, K., and Dresner, M., 2007. Environmental determinants of VMI adoption: an exploratory analysis. *Transportation Research Part E: Logistics and Transportation Review*, Vol. 43, No. 4, pp. 355-369.

Elvander, M.S., Sarpola, S., and Mattsson, S.-A. 2007, Framework for characterizing the design of VMI systems, *International Journal of Physical Distribution and Logistics Management*, Vol. 37, No. 10, pp. 782-798.

Galasso, F., Mercé, C. and Grabot, B. 2009, Decision support framework for supply chain planning with flexible demand, *International Journal of Production Research*, Vol. 47, No. 2, pp. 455-478.

Gröning, A. and Holma, H. 2007, *Vendor managed inventory: preparation for an implementation of a pilot project and guidance for an upcoming evaluation at Volvo Trucks in Umea,* Master's thesis. Lulea University of Technology.

Hines, P., Lamming, R., Jones, D., Cousins, P. and Rich, N. 2000, *Value Stream Management: Strategy and Excellence in the Supply Chain*, Financial Times, Prentice-Hall, Englewood Cliffs, NJ.

Holweg, M., Disney, S., Holmström, J. and Småros, J. 2005, Supply Chain Collaboration: Making Sense of the Strategy Continuum, *European Management Journal*, Vol. 23, No. 2, pp. 170-181.

Hoover, W.E., Eloranta, E., Holmström, J. Huttunen, K. 2001, *Managing the Demand-Supply Chain.* New York, John Wiley & Sons, Inc.

Kaipia, R., Holmström, J. and Tanskanen, K. 2002, VMI: what are you loosing if you let your customer place orders? *Production Planning & Control*, Vol. 13, No. 1, pp. 17-25.

Marqués, G.,Thierry, C., Lamothe, J. and Gourc, D. 2010, A review of Vendor Managed Inventory (VMI): from concept to processes, *Production Planning & Control,* Vol. 21, No. 6, pp. 547-561.

Min, S., Roath, A.S., Daugherty,P.J., Genchev, S.E. Chen, H. and Arndt, A.D. 2005, Supply chain collaboration: what's happening?, *The International Journal of Logistics Management,* Vol. 16, No. 2, pp. 237-256.
Rusdiansyah, A. and Tsao, D.-B. 2005, Coordinating deliveries and inventories for a supply chain under vendor managed inventory system. *JSME International Journal, Series A, Solid Mechanics and Material Engineering*, Vol. 48, No. 2, pp. 85-90.
Simatupang, T.M. and Sridharan, R. 2005, An integrative framework for supply chain collaboration, *The International Journal of Logistics Management*, Vol. 16, No. 2, pp. 257-274.
Waller, M., Johnson, M.E. and Davis, T. 1999, Vendor managed inventory in the retail supply chain, *Journal of Business Logistics*, Vol. 20, No. 11, pp. 183-203.

FUNCTIONALITIES OF THE DECISION-MAKING SYSTEM FOR INTERMODAL RAILROAD OPERATIONS

Jukka Hemilä
VTT Technical Research Center of Finland
P.O. Box 1000, 02044 VTT, Finland
Tel: +358 40 820 8084, Fax: +358 20 722 5888
Email: jukka.hemila@vtt.fi

ABSTRACT:
The research project EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe, and Environment-Friendly Logistics) is now implementing a developed ICT platform for the transport sector and realizing the Intelligent Cargo concept. Intermodal railroad operations are today a great challenge for intermodal operators due to the lack of information for decision making. This paper presents the functionalities of the decision-support system for intermodal operators. The idea is that railway wagons manage themselves as much as possible based on the rules and decisions made by the transport manager.

Keywords: decision-support system, intermodality, Intelligent Cargo

Introduction and background

Today's industrial business environment is so complex that the management and decision makers need support from information and communication technologies. Decision-support systems (DSS) have been a topic of research and development for over two decades. Decision-support systems are software systems that should have the following characteristics (Parker, 1986):

- assist users in semi-structured decision tasks,
- support managerial judgment,
- improve the effectiveness of decision making,
- combine use of models with databases,
- can be used by non-computer specialists in an interactive manner, and
- adapt to the decision-making approach of the user.

DSS is widely used in different kinds of business environments, and also in logistics and transportation. In transportation, information technology is largely applied in the generation and development of Intelligent Transportation Systems, or ITS (Jianwei et al., 2010). The term ITS is generally used to refer to tomorrow's technology, infrastructure, and services, as well as the planning, operation, and control methods to be used for the transportation of persons and freight (Crainic et al. 2011). ITS is not a new topic, but over the last 15 years or so, we have already seen tremendous efforts aimed at creating and deploying a new generation of transportation systems that aim to control congestion, increase safety, increase mobility, and enhance the productivity and effectiveness of private and public fleets (ibid.). ITS developments have been up to now largely hardware-driven and have led to the introduction of many sophisticated technologies in the transportation arena, while the development of the software component of ITS, models and decision-support systems in particular, is lagging behind (Crainic et al. 2011). The motivation for the EURIDICE project was the lack of a common decision-support system supporting all kinds of logistics and supply chain management using not only modern software solutions, but also the latest hardware technologies. The EURIDICE project involves a cargo-centric information infrastructure and intelligent participation. Status information (virtually) accompanies the cargo along the flow of goods and enables interaction with the surrounding environment and users (EURIDICE Deliverable D11.1, 2009). By adding a cargo-centric information flow to the current legacy systems, the integration and participation of a large group of inhomogeneous organizations can be established in an easy and transparent way. Intelligence is added by making the cargo self-aware, context-aware and connected in order to reduce the operational effort involved in handling goods at the right time in the right way. The EURIDICE project itself will be considered to be successful when it can provide a simple solution for cooperation by establishing a basic infrastructure for cargo users that will lead to mass adoption. Our objective is to produce relevant benefits for businesses and society, such as (ibid):

- Enhanced and widespread capability to monitor, trace, and safely handle moving goods at the required level of detail, from full shipments to individual packages or items;
- Increasing the efficiency of transportation networks by improving synchronization between logistic users, operators, and control authorities;
- Improving the sustainability of logistic systems by reducing their impact on local communities in terms of traffic congestion and pollution.

The EURIDICE solution is developed according to these requirements and now the project is proceeding into the implementation phase. Earlier we presented the development of the technological solution (Hemilä, 2010) and the use of agent technologies (Schumacher et al. 2010) at the ISL conferences. This paper presents a solution developed for intermodal operations, the kind of functionalities it has, and the way it will be implemented and evaluated. The paper analyzes how stakeholders can benefit from the new platform.

Methodology and Research Approach

This research is part of the FP7 project called EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe, and Environment-Friendly Logistics). The research is based on the constructive research methodology. A new construct for Intelligent Cargo is developed and it will be implemented and tested within multiple case studies (Yin, 2003). The paper discusses which kinds of functionalities have been developed for the common solution and how the solution will be implemented and tested within a single case study. Our pilot application is for an intermodal operator in Finland. Development began with the analysis of business processes and setting the objectives for the final application. The final application requirements were collected from all stakeholders and end-users. The development process had many iteration rounds between the developers and end-users in order to ensure the development of the required functionalities. While development was ongoing, the researchers created assessment methodology. Assessment will be done after the implementation in order to analyze the advantages of the implemented solution.

Functionalities of the EURIDICE Architecture and Platform

The EURIDICE platform is open and scalable, allowing users to use EURIDICE services from data acquisition to automated transactions, intelligent data analysis, and decision support (EURIDICE Project White Paper, 2009). The EURIDICE approach is cargo-centric with individual cargo objects (item, pallet, or cargo unit) being able to exchange data for decision-making purposes (ibid.).

The functional viewpoint focuses on the required capabilities (categories of high level services) that the EURIDICE high level architecture has to offer. The proposed EURIDICE Infrastructure will cooperate with existing and business specialized (legacy) systems with use of Specific Gateways for Legacy systems. The EURIDICE software components are organized in three categories (EURIDICE Deliverable D11.1, 2009):

- Core services required to provide the basic capabilities of the EURIDICE architecture;
- Services that are recommended to support the supply chain but which are not primarily required;
- Business-specific services to support the pilots in particular.

Within each of the abovementioned categories, the following sub-classification is used:

- Generic but non-business-related services required to provide a basic infrastructure for the supply chain-related services. The communication (containing gateways and routing services), the security services, and the Service Level Agreement management services are part of the proposed Virtual Service Point, which is an implementation of this framework;
- Fixed services that are deployed on fixed platforms as back-end services to facilitate the end-user applications;
- Mobile services that are deployed on mobile devices to collect and provide local information, take local decisions, and provide local support for end-user applications in the field.

The following categories of actors are identified for the platform architecture: discovery services, authentication services, sensors, and external services. A number of interfaces between the services and the EURIDICE platform have been defined (see the arrows in Figure 1).

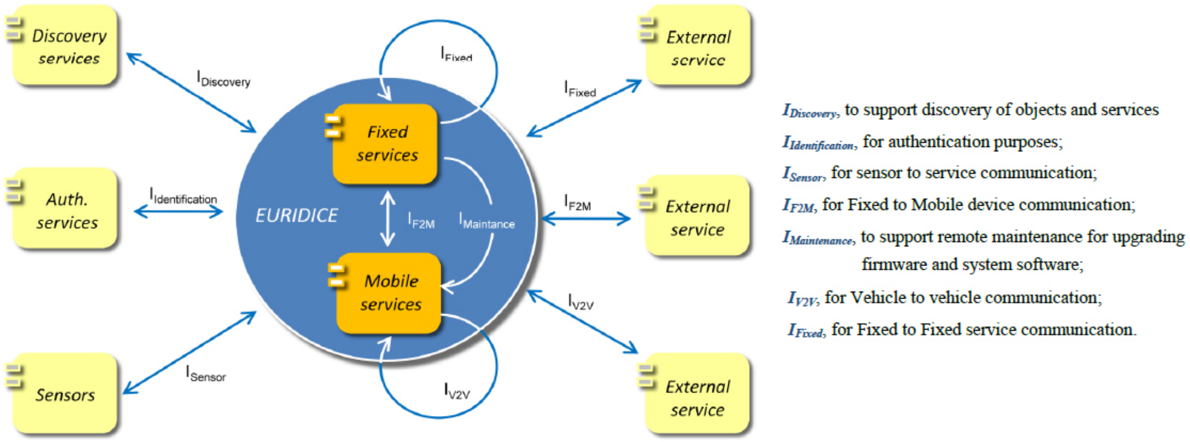


Figure 8 Communication protocols used in EURIDICE (EURIDICE Deliverable D11.1, 2009)

Intelligent Cargo capabilities will be realized with the EURIDICE Software components and services. The Intelligent Cargo capabilities are self-identification, context detection, access to services, status monitoring and registering, independent behavior, and autonomous decisions (Hemilä, 2010). The end-user applications are developed to use common services from the EURIDICE platform.

Decision Support System for Intermodal Operators

The developed EURIDICE Platform provides basic services. Eight industrial end-user cases will implement the platform. One of the cases involves cargo-assisted intermodal transport, which in practice means the implementation of an intermodal operator decision-making system. The case involves the intermodal operator SeaRail in Finland. The test will be realized on the Rauma – Drammen route, on which paper rolls will be transported on the long-term leased wagons of SeaRail during a three-month test period. The paper rolls are produced in Rauma, from where the rolls are transported by truck to a warehouse at a railway yard in Rauma. From there, the paper rolls are loaded onto the wagon . The railway operator takes care of the haulage of empty wagons to Rauma and the transportation of the loaded wagons from Rauma to the Port of Turku. Bogie/axle changes will be performed in Turku due to the different railway gauge outside Finland. Wagons are moved into the port area and onto a ferry. The scheduled ferry haulage between Turku and Stockholm is not the focus of the test. Transportation from Stockholm via Hallsberg in Sweden to Drammen in Norway is done by the Swedish railway operator. The railway terminal takes care of unloading in Drammen into a warehouse or onto a truck. Customs are involved at the harbors of Turku and Stockholm.

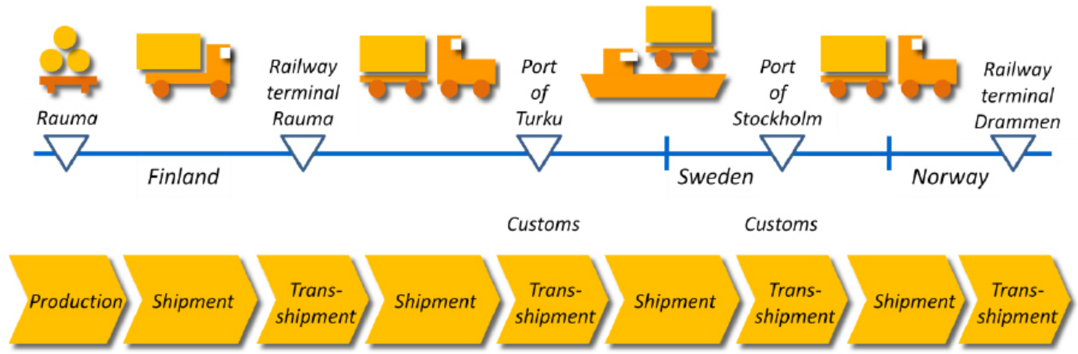


Figure 9 The logistics process of the intermodal operator case (EURIDICE Deliverable D11.1, 2009)

The objective of the pilot application is to improve customer service and the efficient utilization of wagons in intermodal operations. The sub-objectives are (Hemilä, 2010):

- Wagons communicate their status, condition, position, and predicted time of arrival, supporting users in the wagon selection process;
- Automated exception detection and alerting from cargo/wagon to the logistic planner for, e.g., delayed or lost cargo, route inconsistencies;
- Real-time monitoring of wagon utilization rates through active cargo/wagon relationships, to support load planning and operations performance evaluation.

The system will be able to facilitate the wagon selection proposal, based on the statuses and locations of the available wagons. One important feature is automated alerting and event information about the wagon. If something unexpected occurs during transportation, the wagon itself notifies or alerts the user. It will be possible for all wagons equipped with the Intelligent Cargo solution to be followed in real time.

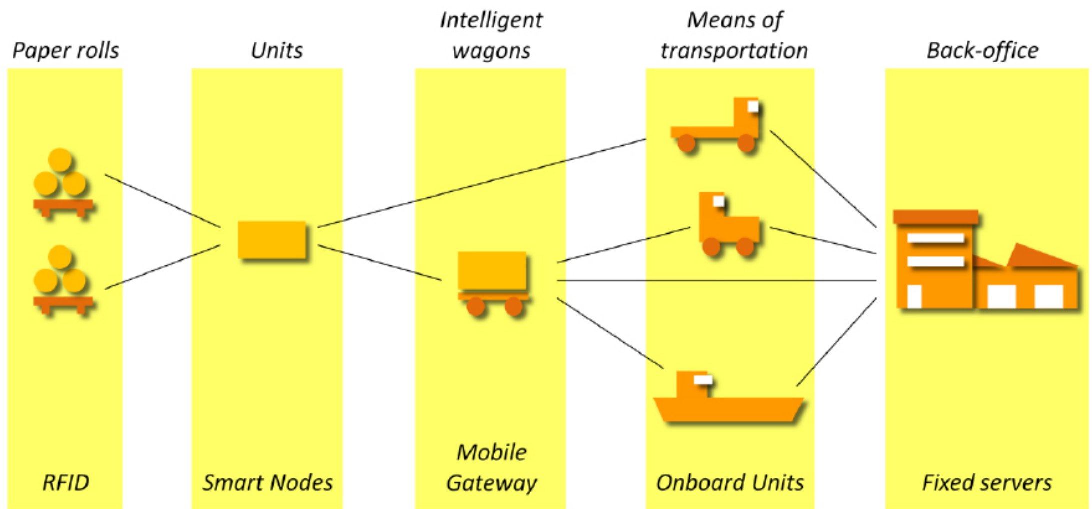


Figure 10 Different types of technologies used in the supply chain (EURIDICE Deliverable D11.1, 2009)

The connection with the legacy ERP systems of the involved stakeholders will be based on the exchange of business documents using web services (SOAP protocol). Communication with the Intelligent wagons will be based on the concept of the Intelligent Cargo Network, using software agents and the selected communication protocol. The fulfillment of sub-objectives is the main motivation for the pilot application. Software functions are the functionalities of the pilot application. The pilot application uses horizontal components and EURIDICE services from the EURIDICE architecture. The following table summarizes the developed functionalities of the system.

Table 4 Summary of the decision-making system software workflow

Sub-objectives	Software functions	Horizontal components	EURIDICE services
Facilitate the proposal of wagon selection	• Propose shipment plan • Find nearest available wagons • Calculate distance in space and time • Get list of ecNodes • Query ecNode • Adjust Shipment Plan • Assign Shipment Plan • Update ecNode	• Communication • Security • Assisting Cargo Agent • Identification • Intelligent Cargo Administration • Object Information • Positioning • Discovery (ecNodes) • Event • Operational Cargo Agent • Shipment planning • Local Reasoning • Global Reasoning	• Route Service • Comparison Service
Automated alerting and event information about the wagon situation	• Manage ecNodes • Query ecNode • Update ecNode	• Communication (Asynchronous) • Security (Authentication) • Assisting Cargo Agent • Identification • Intelligent Cargo Administration • Object Information • Positioning • Discovery (ecNodes) • Event • Operational Cargo Agent • Local Reasoning • Global Reasoning	• Conditions monitoring • Route Service
Automated calculation of utilization rates	• Calculate utilization rates • Get list of ecNodes • Query ecNode • Update ecNode • Send KPI calculations to ERP	• Assisting Cargo Agent • Intelligent Cargo Administration • Local Reasoning	• Rule engine • Reporting

From the business point of view, the automated calculation of wagon utilization rates is required. The system can calculate the Key Performance Indicators based on the collected data from the transport process. All core and most of the recommended software components identified as part of the EURIDICE solutions are applicable for the SeaRail pilot case. When the set objectives can be achieved, then this pilot case will prove that the EURIDICE (intelligent cargo) concepts are useful.

Concluding Discussion and Future Work

EURIDICE has developed a Cargo Intelligence solution in which cargo is self-aware, context-aware, and connected to stakeholder systems (EURIDICE Project White Paper, 2009). The developed and implemented platform will contribute to the realization of the future transport vision, in which European freight corridors will be “intelligent” within five years (ibid.). What makes EURIDICE unique?

- A cargo-centric approach to add a “horizontal” information flow across the vertical process approach that is in use today;

- An end-to-end information chain for the logistic supply chain;
- The constellation of existing technologies and standards combined with intermediating trusted third parties;
- The option to adopt the EURIDICE architecture gradually, depending on the needs and available resources of the participant;

As there is no common transport and logistics management and decision-support system available on the market, the EURIDICE platform is warmly welcomed by supply chain stakeholders.

Implementation, assessment, and evaluation are the next steps in the project. Test periods have been set for the performance indicator targets. The technological solution has been developed with a view to supporting the business requirements of end-users; it will be evaluated later to provide an overview of how well it really improves business processes.

REFERENCES

Crainic T G, Gendreau M, Potvin J-Y (2009) "Intelligent freight-transportation systems: Assessment and the contribution of operations research" in Transportation Research Part C: Emerging Technologies, Volume 17, Issue 6, December 2009, Pages 541-557

EURIDICE Deliverable D11.1 (2009) "EURIDICE – High Level Architecture Overview", v2.0 of 10th November 2009. Available at: www.euridice-project.eu.

EURIDICE Project White Paper (2009). Available at: www.euridice-project.eu

Hemilä J (2010) "Cargo Intelligence for Intermodal Operations" in Proceedings of the ISL2010. Kuala Lumpur, Malaysia, 4-7 July 2010.

Jianwei H E, Zhenxiang Z, Zhiheng L (2010) "Benefit Evaluation Framework of Intelligent Transportation Systems" in Journal of Transportation Systems Engineering and Information Technology, Volume 10, Issue 1, February 2010, Pages 81-87

Parker B J, Al-Utaibi G A (1986) "Decision support systems: the reality that systems find hard to accept?", OMEGA 14 (1986)p. 135-143.

Schumacher J, Rieder M, Gschweidl M (2010) "Euridice – Platform Architecture for Pro-Active and Autonomous Logistics Operations." Proc. of the ISL2010.

Yin R (2003) "Case study research - design and methods". 3rd edition, Applied social research methods series; v. 5. Sage Publications, Inc. 2003

MANAGEMENT OF THE 'SHIPPER – LOGISTICS SERVICE PROVIDER' RELATIONSHIP

Job de Haan, Mark Overboom, Fons Naus and James Small
Department of Organization and Strategy, Tilburg School of Economics and Management, P.O. box 90153, 5000LE Tilburg, the Netherlands; J.A.C.DEHAAN@UVT.NL

ABSTRACT
Logistics service providers (LSPs) serve as an intermediate between shippers and their customers to create the value shippers aim at. However, it is not always clear what this value is neither to the LSP nor to the shipper. We develop and test a Customer Process Analysis (CPA) tool to identify the nature and level of key performance requirements set by shippers, and the extent to which these requirements are met by LSPs. The CPA is a hierarchy of performance indicators used to determine the level of fit. CPAs were carried out at 9 companies and the findings were, at first sight, disappointing. Hardly any of the LSPs had defined any type of performance indicator nor its required level, furthermore shippers were also not able to provide this information when asked. A number of the larger LSPs had indeed defined and applied internal performance indicators, but they used the same indicators for all of their customers and thus are not customizing these indicators to all for the fact that different customers may have different demands.

Keywords: logistics service provider, buyer-supplier relationship, performance measurement

INTRODUCTION
Logistics service providers (LSPs) serve as an intermediate between shippers and their customers to create value for the shippers. Therefore, LSPs must measure the value created to their customer as well as throughout the supply chain (Lambert and Burduroglu, 2000). LSPs are more optimistic about their role in logistics success of their customers than the shippers themselves are, although the latter are pretty satisfied in the end (Langley and Capgemini, 2009). Their relationship is a very specific type of buyer-supplier relationship, because three parties are involved: LSPs serve, in part, the clients on behalf of the shippers, whereas shippers are responsible for the overall result (Bask, 2001). Although many shippers treat price as the most important selection criterion for LSPs, they may occasionally be unhappy with the LSPs' performance. However, this lack of satisfaction with the LSPs performance may not emerge directly in the immediate relationship, but indirectly because of unsatisfied clients due to the LPS' performance. It seems that all too often LSPs and their customers use measures they are familiar with, but they do not know if they are appropriate for their measurement needs or not (Griffis et al., 2004). To overcome these problems we develop and test a Customer Process Analysis (CPA) tool in this paper. This tool serves two purposes (a) to identify the nature and the level of key performance requirements set by shippers, and (b) to determine the extent to which these requirements align with the way LSPs carry out their key processes. The theoretical proposition is that the better the fit is between measurable performance demands and process performance the higher customer satisfaction and retention will be. This in turn will have a beneficial overall effect on LSP productivity (Innis and Lalonde, 1994). In the customer-process analysis (CPA) a hierarchy of performance indicators is used to determine the level of fit.

The remainder of the paper is organized in three sections. In the next section the theoretical model underlying the research is developed. We combine results from Operations management, i.e. performance measurement and Marketing, i.e. the influence of customer satisfaction on customer retention. From this we develop a hierarchy of performance indicators starting with demands made by various (groups of) customers at the strategic level. Then these indicators cascade down into different sets of performance indicators used in primary LSP processes at the operational level. Then we apply this model in a larger, longitudinal project on lean logistics in which several tools are applied at LSPs during their lean journey (De Haan et al., 2009). Based on documents, interviews and observations, customer demands are identified as well as the processes that are supposed to meet these demands. After the presentation of the results, we discuss their theoretical and practical implications for improving the shipper (customer) -LSP relationship.

THEORETICAL MODEL

Customer satisfaction is 'a customer's overall evaluation of the performance of an offering to date' (Gustafsson et al., 2005, 210). Shippers and LSPs can have quite different views on the setting of service levels and LSPs tend to overestimate their performance when compared with the shippers' evaluation (Langley and Capgemini, 2009). Whether the shipper evaluates the performance positively, does not only depend on the performance as such, i.e. in accordance with expectations, but also on the evaluation of the shippers' clients as far as the outsourced activities are at stake. Shippers can operate in different markets urging them to adapt their strategy to these markets. Traditionally, Porters' low cost leadership and differentiation strategies are mentioned as the extremes. In the first strategy, low costs should bring high satisfaction as the key determinant of performance as perceived by the shipper whereas if differentiation is pursued, the degree of customization of the services as perceived by the shipper influences satisfaction. Thus fundamentally, LSPs should be aware of the strategy the shipper pursues.

As the overall evaluation builds up over time, satisfaction may mediate the effects of e.g. product quality on loyalty. The evaluation may also contain an affective component as a result of the repeated product usage. Relationship marketing enhances value to the customers because it increases satisfaction levels on transactions (Minami and Dawson, 2008). Although developed for consumer marketing we will apply it for industrial marketing. If customers appreciate the value provided by a supplier, they are expected to improve the relationship with the firm involved. Such a customer enjoys the value created by the supplier as well as other intangible benefits and in turn creates value for the supplier either through additional income or through reduced costs. When firms invest by doing business, they learn more about each other and each other's business. Such investments are often a key to success, in logistics just-in-time delivery is an example (Eriksson and Lofmark Vaghult, 2000). In the end relationship marketing creates a sequential effect through customer satisfaction to customer retention and can lead to improved financial outcomes (Minami and Dawson, 2008).

Although different approaches exist to focus operations and resources, Hill (2008) shows that the order-winners and qualifiers approach shows the best results to organize operations. This approach reduces the size of operations as well as creates a single and coherent task. In one of his case studies, for example, a firm split its products into a price-sensitive unit and a delivery-sensitive unit. Furthermore, Slack and Lewis (2011) propose performance criteria, which can operationalize order winners and qualifiers, as a starting point for improved operation organization. The services provided to a shipper consist of various processes carried out by the LSP, e.g. transportation requires planning, loading, driving and unloading. Hence the LSP should identify order winners and order qualifiers. They should also organize the related processes in such a way that they can meet the performance criteria required by the shipper by defining key performance indicators: KPIs. Once the KPIs are established, a Polar diagram can show whether they are met for a certain service, figure 1 (Slack and Lewis, 2011).

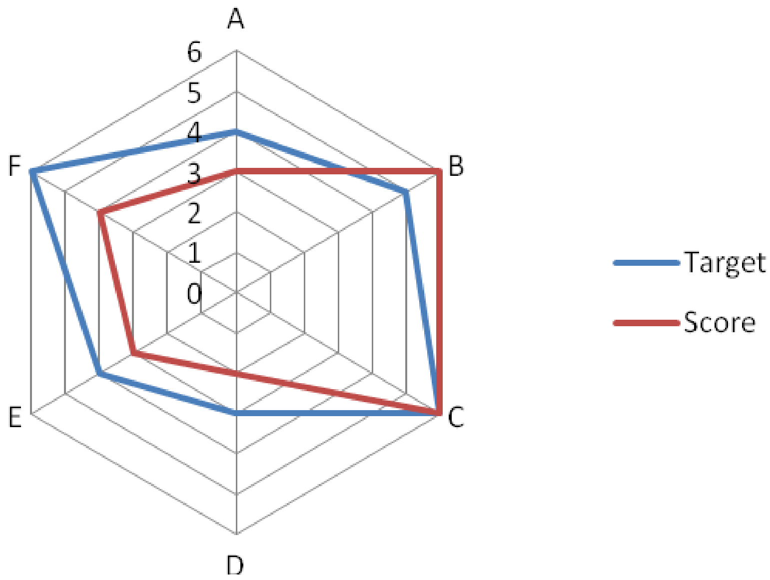


Figure 1 example of a polar diagram

If the LSPs’ processes are not sufficient to meet the agreed service levels, a hierarchy of performance indicators can measure which of these processes fail. Similar to the approach of the SMART as well as the SCOR approach, lower levels synthesize in higher ones. For each service the related process have to be identified as well as for each of the processes that contribution to the KPI, hence PIs for the processes are established. Together the PIs for the activities constitute the PI for the processes and these in their turn for services, either summed up as for time or multiplied as for quality issues. Again actual performance can be measured against preset norms in Polar diagrams, showing whether each of the processes contributes as expected. This requires alignment of performance criteria in the triad, in particular between the LSP and the shipper if the partners are to cooperate more effectively. Misalignment will cause tensions in the relationships (Rey-Marston and Neely, 2010). In many companies, performance measures are only poorly defined which causes a lot of misunderstanding (Nudurupati et al. 2011). The polar diagram shows which process contributes most to not meeting the requirements; hence this process is to be improved first.

Thus, to identify whether an LSP provides value to the customer as required a four staged Customer-Process-Analysis (CPA) can be applied:

- Analyze customer base and select a (pilot) customer
- Analyze required performance based on order winners and order qualifiers on services delivered to the customer (KPI)
- Analyze internal processes carried out to deliver required services
- Assess performance of processes against customer requirements (PI vs KPI)

RESULTS

As part of a larger project on implementing lean in LSPs for nine companies a baseline CPA was prepared. The goal was to find out to what extend these companies indeed created the value their shippers expected. The data collection followed the procedure as developed above. At first company documents were collected and if not available we complemented these with results from interviews with management and other employees involved in the processes being investigated.

Due to the scope of this paper we present the results on only four of the companies. These were chosen because of the level to which they meet the requirements of the CPA-tool. They are presented in descending order of fit in the tables 1 and 2.
In table 1 the customer base of the four selected LSPs is presented
Table 1: Customer base

COMPANY	GHT	IMT	KDE	CVT
NO. OF CLIENTS	25	13	185	341
NO. CLIENTS GIVING 80% OF TURNOVER	4	4	24	62
CONTRIBUTION LARGEST CLIENT	24	4	22	12.5
NO. OF CLIENTS > 1.5% OF TURNOVER	25	31	16	15
SELECTED CLIENT	G.P. (FMCG MANUFACTURER) LARGEST AND MOST PROMISING CUSTOMER	I. SPECIAL AND I. STANDARD; LARGEST AND MOST PROMISING CUSTOMERS	3 CATEGORIES: TRANSPORTATION (T), T AND WAREHOUSING (W) AND T, W AND CROSS DOCKING (C). ANALYSIS: F, PRO-MISING NEWCOMER FROM T,W AND C	3 CATEGORIES: TRANSPORTATION, TRANSPORTATION AND CROSS DOCKING, TRANSPORTATION, CROSS DOCKING AND WAREHOUSING

From table 1 we learn firstly that major differences exist between the four LSPs. On the one hand we see GHT and IMT which have a limited number of large clients and on the other hand we see KDE and CVT which have over 100 clients most of them very small. The practices with respect to customer relationship management differ considerably among these two groups. Those with a limited customer base are more or less dedicated service providers who could enter into a close relationship with the shippers. However, those with a wide customer base simply can’t. This is even further complicated because these are relatively small LSPs. However, even under such conditions KDE managed to select a relevant customer to do the CPA.

In table 2 the results of the CPA on services and their KPIs as well as related processes and their PIs and the confrontation of KPIs and PIs as far as possible are presented.
Also from table 2 lessons can be learned. A remarkable finding is that the shippers are not transparent with respect to what they expect from their LSPs. IMT even asked the

Table 2: CPA results for the LSPs

Company	**GHT**	**IMT**	**KDE**	**CVT**
Services and performance	• Transportation • 3 KPIs are used: on-time-delivery (OTD), feedback on deviations (FOD), inventory check for traceability (ICT)	• Warehousing • SLA: only what services not performance level. Clients mentioned KPIs, not level even when asked for • standard: speed, OTD, Cost-of-delivery (COD), Inventory management (IM) • I. special: Order fill rate (OFR), order cycle time (OCT), OTD.	No KPIs for or SLA with F, from experience employees and management know that speed, consistency, flexibility and reliability are order winners and malfunction recovery and costs are order qualifiers	No data on KPIs or SLA, from experience and social, longstanding relationships: T: costs, reliability and flexibility; T+C: idem + speed; T+C+W: idem + quality
Processes and services	For Transportation: order entry, planning, transportation and documentation are applied. No PIs are distinguished for each process. PIs exist for OTD(1), FOD (5) and ICT (1)	IMT has a standardized service package: reception, order release, picking, packing, truck planning, storing, loading and transport. Each has a number of PIs. Customers can have special arrangements: on inventory, on orders or value added services	Transportation: outbound and its planning, warehousing: from bulk reception through value adding picking and repackaging to shipment. Internally, implicit PIs exist for processes. On time and food safety (for 5 processes), in full and no damage (for 3) and speed and costs (1)	T consists of driving and (un)loading, C of unload, check and reload and W of storing, picking, packing and move to dock
PI versus KPI	Only overall performance on client-service level is made: OTD mixed, FOD exceeds and ICT exceeds	For various processes internal PIs are distinguished. For I. standard: transport: speed (2 PIs) and OTD (1), order release (-), pick (-), load (-) and load (5) add to COD and reception (1) and storing (4) to IM. I. special picking (3) and truck planning (1) add to OFR, order release (-), picking (1) and packing (-) to OCT and transport (1) to OTD.	As both the external KPIs and the internal PIs are implicit no formal performance analysis can be made	Work pressure and complaints are informal non-measured standards

customers they tried to analyze with the CPA about their KPIs. It took some time to analyze their answers to understand to which performance indicators these shippers apparently referred. The LSPs on the other hand seem from their long experience with some of their customers to know what the latter require.

The services the LSPs provide consist of different internal processes and for most of these processes PIs are in use, but not for all. In some cases different PIs are in use to measure the same performance criterion.

PI versus KPI analysis is only, partly, possible for GHT and for IMT, as is shown in figure 2 a and b respectively. GHT can at the service level compare what the customer wants with its actual performance, but not at the process level. IMT knows the KPIs the customer wants, but can't make a proper polar diagram as the level of the KPIs are unknown. Furthermore, no overall performance can be calculated because in some cases no PI exists and in other cases several competing PIs exist.

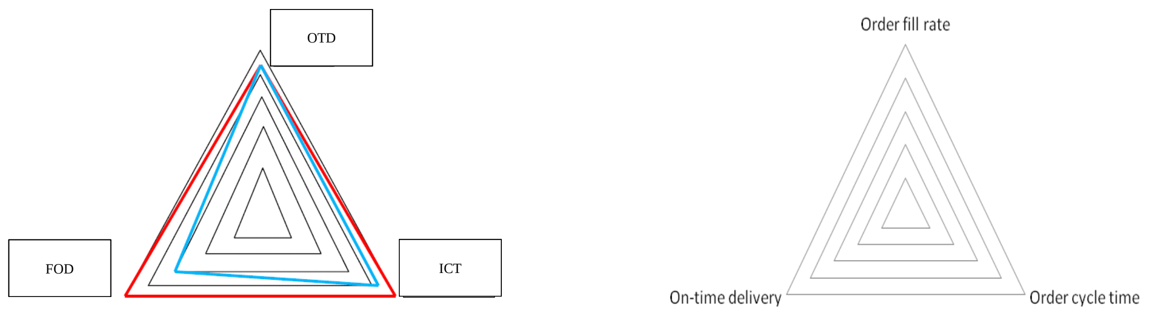


Figure 2 Performance analysis, a: at GHT and b: at IMT

DISCUSSION

To play their role in the triad properly, LSPs have to measure their customers' needs (Lambert and Burduroglu, 2000) as well as their contribution to the logistics success of their customer (Langley and Capgemini, 2009). To be able to measure the contribution to value creation, LSPs (and their shippers) need not only to have measures, but they need appropriate ones (Griffis et al., 2004).

Customer Process Analysis, the tool developed during this research serves two goals: identifying the appropriate performance measures and analyzing to what extent requirements are met.

The preliminary results show that in the cases analyzed the appropriate measures hardly could be identified. KDE and CVT did define KPIs but these were based on their own experiences only, and what they think their customers' order winners and related KPIs are. If they are right on this, this could explain the lengthy relationship they have with some of their customers, which seems to be in line with Langley and Capgemini's findings (2009) that shippers are rather satisfied with the LSPs' performance. Apparently, the investments Eriksson and Lofmark Vaghult (2000) refer to are made. However, the lack of clarity of PKIs from the side of the shippers suggests that LSPs are more eager to do so. Of course the number of clients plays a role, but KDE and CVT were not able to define order winners or KPIs for groups of customers either. Hence, they cannot determine to what extent a fit between KPIs and actual performance exists. Furthermore, even large companies with only a limited number of clients, such as IMT, don't know their customer requirements. However, when they asked their customers about KPIs and performance levels the answers were also not very revealing either. Only GHT established a number of relevant KPIs as well as the required performance levels. These findings are difficult to reconcile with the claim that LSPs create value for their shippers and in the end for the latter's' clients. Yet shippers acknowledge the LSPs' role in their logistics success, whether the investments Eriksson and Lofmark Vaghult (2000) refer cause requires further research. However, CPA provides the LSPs and their shippers with the opportunity to identify which the relevant KPIs for the various services delivered should be, based on the identification of order winners. In addition to this, it allows firms to determine the hierarchy of PIs for processes contributing to these services should be, as well as the activities contributing to the processes.

The shipper should be satisfied, once the requirements with respect to the appropriate performance measures are met. These KPIs should reflect the criteria for the overall evaluation of the performance of an offering to date (Gustafsson et al., 2005). Hence the sequential effect Minami and Dawson (2008) expect: customer satisfaction, customer retention and improved financial outcome, should occur. Langley and Cap Gemini's findings (2009) show that LSPs' overestimate their performance when compared with the shippers' evaluation. However, the question is: can and do they know what their performance should be? LSPs cannot know this because of the lack of KPIs expressed to them by the shippers. However, when shippers express the KPIs, the LSPs know as shown in case of GHT. On one of the three known KPIs they underperform, however, but which process is most responsible for this can't be analyzed because no internal PIs are used. IMT on the other hand knows now the areas which are crucial to the customer, but does not know about the required performance level. However, they have internal PIs which could show to what extent each of the processes that contribute to the service meets the required performance level to meet the overall required performance level. Resulting from that, the process with the largest gap between the norm and required performance can be selected for improvement.

To conclude the CPA combines insights from Marketing (e.g. customer satisfaction, customer retention, relationship management); Supply chain management (e.g. shipper, customer and LSP triad) and Operations management (performance measures (KPIs, PIs) into one tool that can be applied in a complex environment like the LSP triad.

Managers (both of LSPs and shippers) can benefit from this tool by identifying the appropriate measures needed to satisfy the customer in their specific triad. In addition to this, it will help them to negotiate realistic (for LSP and shipper) performance levels ex ante as well as assess performance ex post. The LSP can focus the organization of the various services on the specific requirements of certain shippers to facilitate performance required. Finally, the LSP can analyze disappointing external performance using an intern hierarchy of PIs. Although all steps mentioned were visible in the LSPs of this study, none of them applied all of them. Hence a lot remains to be done before LSPs can measure created value to their customers and the triad in which they perform.

REFERENCES

Bask, A., Relationships among TPL providers and members of supply chains – a strategic perspective, *Journal of Business & Industrial Marketing*, 16, 6, 470-486, 2001

Cai, J.,Liu, X., Xiao, Z., and Liu, J., Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment. *Decision Support Systems*, 46, 512-521, 2009

Eriksson, K., Lofmark Vaghult, A., Customer retention, purchasing behavior and relationship substance in professional services, *Industrial Marketing Management*, 29, 363-372, 2000

Griffis, S., Cooper, M., Closs, D., Goldsby, T., Performance measurement: measure selection based upon the firm goals and information reporting needs, *Journal of Business Logistics*, 25, 2, 95-118, 2004

Gustafsson, A., Johnson, M. and Roos I., The effects of customer satisfaction, relationship commitment dimensions and triggers on customer retention, *Journal of Marketing*, 69, 210-218, 2005

Haan, J.de, Overboom, M. and Naus, F., Lean logistics service providers: option or utopia? Experiences from the Netherlands, *Proceedings of the 5th international congress on logistics and SCM systems* 243-249, 2009

Hill, A., How to organize operations: focusing or splitting?, *International Journal of Production Economics,* 112, 646-654, 2008

Innis, D. and Lalonde, B., Customer service: the key to customer satisfaction, customer loyalty and market share, *Journal of Business Logistics*, 15(1), 1-23, 1994

Lambert, D., Burduroglu, R., Measuring and selling the value of logistics, *International Journal of Logistics Management,* 11, 1-17, 2000

Langley, C. and Capgemini U.S. LLC, *The state of logistics outsourcing: 2009 third-party logistics*, 2009
Minami, C. and Dawson, J., The CRM process in retail and service sector firms in Japan: loyalty development and financial return, *Journal of Retailing and Consumer Services*, 15, 375-385, 2008
Nudurupatti, S., Bittici, U., Kumar, V.,, Chan, F., State of the art literature review on performance measurement, *Computers & Industrial Engineering*, 60, 279-290, 2011
Rey-Marston, M., Neely, A., Beyond words: testing alignment among inter-organizational performance measures, *Measuring Business Excellence*, 14, 1, 19-27, 2010
Slack N. and Lewis, M., *Operations strategy*, 3rd ed., Financial Times/Prentice-Hall, Englewood Cliffs, NJ, 2011
Acknowledgement: This paper is part of the 'Lean Logistiek, meer waarde door mensen' funded by MidPoint Brabant. The authors appreciate highly this contribution to social innovation in the region!

EXPLORING OUT-OF-STOCK AND OVER STOCK OCCURRENCES IN SUPERMARKETS – A CASE STUDY IN SINGAPORE

Elsie Hooi, Booi Kam, George Cairns
School of Business IT and Logistics
RMIT University
Melbourne
Australia 3000

ABSTRACT
This paper examines in-store processes for the management of on-shelf availability (OSA) of stock to avoid out-of-stock (OOS) or over stock (OS) occurrences. The study employs a single-organization case study with multiple exemplars, based upon a supermarket chain in Singapore. Previous research on OSA of stock looked at issues such as: consumer responses to stockouts, influence of product assortment, OSA management issues, the use of technology to improve OSA of stock, inventory planning, and ordering processes. Relatively few studies have been conducted on the management of in-store operations, especially on the "last 50 yards" of the supply chain. The research employed a qualitative approach to investigate in-store processes, OOS and OS occurrences. A series of semi-structured interviews were conducted with 20 store managers within the supermarket chain. After each interview, on-site observations of their in-store operations were also conducted.

In-store processes of this supermarket chain that caused OOS and OS events include: store-based ordering, receiving, replenishment, packaging, and staff-related issues. The adoption of information technology to improve these areas has resulted in varied outcomes due to staff attitudes and competence as well as service performance of the suppliers. Results showed that offering employees incentives to ensure OSA can only be effective at certain stages of in-store operations. Senior management need to develop strategies at respective employee levels to include OSA of stock and back store management to encourage employees' understanding on how OSA of stock can affect continual store patronage, and should incorporate this issue in employee performance evaluation. Different configurations of packaging, with their respective pricing, need to be profiled in the information systems of the supermarket chain to improve accuracy in store-based ordering and at checkout stations. Whilst prescribed in-store processes have been advocated to achieve OSA of stock, employees should be empowered to vary implementation of in-store processes based upon experience and context in order to achieve required outcomes.

Keywords: In-store process, out-of-stock, over stock, supermarkets.

Introduction

Grocery retailers face constant challenges in offering a plethora of products and services to satisfy customers' demands and in controlling costs to support such offerings. Failure to do so can see grocery retailers suffer high operating costs and poor patronage due to regular OOS and OS occurrences (ECR Europe 2005; Goswami & Mishra 2009) in an intensively competitive environment, where not only customer patronage is critical but also store loyalty (Miranda, Kónya & Havrila 2005). With both as desired performance indicators, grocery retailers must ensure they offer the right product, at the right time, the right price and the right place. If any 'rights' are not achieved, the risk of losing customers becomes a reality. As such, grocery retailers must ensure they receive the right stock, place the stock at the right place and ensure high turnover products are in constant supply (Corsten & Gruen 2003).
In-store processes and activities, such as product assortment, shelf space allocation and management, and inventory management have been found to affect OOS and OS occurrences (Aastrup & Kotzab 2010; ECR Europe 2005; Hariga, Al-Ahmari & Mohamed 2007; Trautrims et al. 2009). Another in-store process blamed for causing OOS is ineffectiveness in transferring goods from the stores' receiving dock onto the display shelves, known as "the last 50 yards of a supply chain" (Grant, D 2004). Other activities

that occur within that process include: receiving of goods, store-based ordering, replenishment, and back store management (ECR Europe 2005).

Through in-depth semi-structure interviews with senior staff from a supermarket chain in Singapore, an understanding was achieved on how respective stores manage their in-store processes; such as inventory management, back store management and replenishment; in order to minimize occurrences of OOS and OS events. On-field observations conducted after each interview, obtained insights into how the respective stores manage their in-store activities, such as receiving goods from suppliers, actual replenishment activities and how store-based ordering was done.

It must be noted that this research does not seek to generalize the occurrences of both phenomena in a grocery retail context, but to achieve an in-depth understanding on how both phenomena occurred in one organization and how the organization managed it in the context of grocery retailing in Singapore.

Literature Review

Though the phenomenon of OSA of stock has been investigated for over 40 years (Aastrup & Kotzab 2010), yet retailers are still struggling to minimize the occurrences of OOS and OS. Causes of both events have been attributed to mismanagement of inventory process, replenishment process, in-store as well as back-store activities (Campo, Gijsbrechts & Nisol 2003; Corsten & Gruen 2003; Fisher, Raman & McClelland 2000; Grant, DB & Fernie 2008; Hausruckinger & Hasse 2003). Other causes of OOS and OS were found to be caused by poor management of product proliferation (Abu-Shalback Zid 2004; Corsten & Gruen 2003), lack of product knowledge (ECR Europe 2005), poor knowledge of consumer buyer behaviour (Gruen & Corsten 2007) and customer reactions to OOS situations (van Woensel et al. 2007). However, Corsten and Gruen (2003) have revealed that a fundamental attribute to OOS events relates to in-store activities, reporting that 72% of the root causes of OOS events occurred inside the store, linked primarily to activities, such as store-based ordering practices, replenishment processes and shelf-based operations, (Corsten & Gruen 2003; Gruen & Corsten 2007). Previous studies on OSA also looked at consumer as well as product variables and characteristics, as they can also affect product turnover (Kotzab & Teller 2005; Svensson 2002). In order to understand how OOS and OS affect stores' level of OSA of stock, we need to look into some of the factors that relate to both phenomena.

Product availability along the supply chain is important to ensure production schedules are maintained, warehouses are adequately stocked and the retail end of the supply chain can provide reliable supplies to their final customers (Hausruckinger & Hasse 2003). In the context of retailing, achieving OSA of stock is to have the ability to offer a reliable supply of goods on the display shelves (Fernie & Grant 2008). It provides a positive experience when customers successfully complete their shopping lists (Grant, DB & Fernie 2008). Customers experience dissatisfaction when they do not manage to complete their shopping lists due to requested purchases not being available or being out of stock (Schary & Christopher 1979). Stores that regularly experience OOS events will face declining customer patronage, and even avoidance from major suppliers as loss of sales affects all parties in the supply chain. OOS and OS occurrences can impact respective parties along the supply chain. Manufacturers and retailers will suffer losses in terms of sales, product loyalty and store loyalty respectively (Corsten & Gruen 2003). Supply chain costs will increase due to inaccurate inventory levels, wasteful activities and poor overall customer service levels (Anderson, Fitzsimons & Simester 2006). OS is an experience to be avoided by retailers as inventory holding costs are high and goods are exposed to risks of pilferage and obsolesces (Chandra & Kumar 2001). In business environments where land is limited, it is even more critical to prevent OS events as unsold goods have to be disposed of below cost or discarded regardless of their use-by-date.

Corsten and Gruen (2003) contended that major activities in planning, store-based ordering and replenishment are attributable to OOS and OS occurrences. Formats of stores have also been linked to OOS and OS occurrences (Messinger & Narasimhan 1997;

Uusitalo 2001) In order to gain a clearer understanding as to where and which activities influenced OOS and OS, the activities were classified in accordance to where they were carried out – inside the store or outside the store. Planning activities conducted outside the stores include transport deliveries, back store management; and activities related to inventory ordering include, manufacturers and suppliers management and the warehouse/distribution centre servicing the stores (Clark 2004; Emmelhainz, Emmelhainz & Stock 1991). Replenishment activities within the stores include product range, product assortment, Planogram, shelf space management and replenishment scheduling. Store-based ordering was also classified as an in-store activity (Corsten & Gruen 2003).

To ensure display shelves are adequately stocked, good inventory management process and replenishment processes are required (Chandra & Kumar 2001; Hausruckinger 2004). To facilitate these processes, manufacturers and producers need to collaborate with retailers to ensure that shelves are stocked and shopper satisfaction can be achieved (Hausruckinger & Hasse 2003). Both parties need to work together to continually improve processes between them in order to achieve sustainable operational accuracy (Corsten & Gruen 2003; Lowson 2001; McKinnon, Mendes & Nababteh 2007). Employees should also be made responsible to ensure on-shelf availability and to use OSA as one of the factors to be considered in employee annual appraisal (Corsten & Gruen 2003). Previous studies in OSA recommended that senior management needs to pay more attention and establish processes to focus on better OSA of stock via customised employee training and communications (Hausruckinger & Hasse 2003; McKinnon, Mendes & Nababteh 2007; Svensson 2002). Modelling to truly understand the cost of OOS and OS as well as optimization of in-store operations and resources has also been suggested in recent studies on OSA (Aastrup & Kotzab 2010; Chopra & Meindl 2007).

The Study

Singapore is a small island with a land area of 712.4 square kilometres and possesses a population of around 5 million people (Department of Statistics Singapore 2011). The grocery supermarket industry is known as Mass Grocery Retail industry and the key players are NTUC Fairprice [local owned], Dairy Farm International [from Hong Kong], Sheng Siong Supermarkets [local owned] and Carrerfour [from France] (BMI 2010). Other players in this industry include wet markets, provisional stores, minimarts, specialists food stores and convenience stores (BMI 2010). The four main players alone have a total of over 650 outlets all over the small island. As such, competition is very intense in this grocery supermarket industry where customers not only enjoy a plethora of product choices at very competitive prices but also where they wish to shop for groceries.

In this research, the grocery retail in-store logistics model developed by Kotzab and Teller (2005) was used as a reference to understand in-store operations of one supermarket chain in Singapore. In Kotzab and Teller's (2005) study, face-to-face interviews were conducted with 202 managers. For this research, in-depth interviews combined with on-field observations were used to obtain a close understanding on store operations. Two rounds of in-depth semi-structured interviews were conducted with senior managers of the supermarket chain. The first interview was aimed at learning and understanding how they managed their warehouse processes to support over 20 individual stores around the island. After transcribing the interview session, as well as further delving into related literature, indicators begin to emerge to understand how they actually manage their in-store operations. Therefore, the second interview with the senior managers focused on understanding how all the stores within the supermarket chain were managed, with emphasis on activities such as inventory ordering, replenishment and back store operations. After the interviews, on-site observations were conducted in each store. In addition, the respective store managers were interviewed, with the aim to obtain observations on how the activities are performed as well as to understand challenges and causes faced by store managers in minimizing OOS and OS occurrences. On-site observations were recommended by Kotzab and Teller (2005) to increase validity of activities that cannot be achieved with interviews.

Data Analysis and Discussions

Kotzab and Teller (2005) developed a grocery retail in-store logistics model to study all logistics process that were carried out within the store, from receiving area to the checkout counters. The model was then empirically tested on dairy products management in 200 stores in the Austrian grocery retail sector. The model was referenced in this research design of data collection and interview questions in order to understand how one supermarket chain managed their inventory management and in-store operations in Singapore.

The head office of this supermarket chain established standard processes pertaining to in-store operations, supplier relationship management as well as the adoption of information technology and management systems, to be applied to all stores under its chain. Stores' performance was determined by financial indicators i.e. profitability of each store as well as the stores' ability to ensure reliable OSA of their FMCG product range (fast moving consumer goods). Interview responses revealed that while majority of the processes were implemented across all stores, the day to day operations reflect varied adherence to the set processes. Demographic factors such as a different mixture of ethnic groups, income levels, size of households and property, availability of competitor grocery stores, affected consumer buying behaviour and reaction to OOS occurrences (Campo, Gijsbrechts & Nisol 2000). Therefore, the stores of this supermarket chain had a certain level of variations in their operations in order to meet the demands of customers located in different parts of the island.

The stores of this supermarket chain managed their inventory levels using a Point-of-Sale system (PoS), which is integrated with the organisation's enterprise resource planning systems (ERP). Hand-held personal digital assistants (PDAs) are used to order, track and receive goods. Store orders are collated in the PDA system and sent through to head office twice a day. Data on product sales are used to analyse product demand and inventory forecasting. However, the integrity of data captured is dependent on accurate usage of both hardware and software of the systems. For example, during peak periods, more errors were reported at the checkout stations, where goods are incorrectly scanned and not rectified immediately. Errors in receiving goods can also affect inventory levels of the affected products, especially when too many suppliers arrive at the same time. Stores of this supermarket chain do not have a system of allocated delivery slots for their suppliers. Suppliers can deliver at any time between 7am and 4pm. The situation is exacerbated during wet weather.

The replenishment process, while standardised for all stores, had different completion times. Reasons for variation include existence of back stores, size of back store, back store management and replenishment times (where staff are on the shop floor re-stocking shelves amongst shoppers). Replenishment is performed during the stores' opening hours, where stacking staff would re-stock shelves and trigger orders where necessary. Stacking staff also conduct visual checks to monitor inventory levels and again, trigger orders via the PDA where necessary. Most stores have back stores but their sizes were relative to the actual sizes of the stores. For example, stores located in the old established neighbourhoods are small, with product offerings of around 3000 SKUs, had very small back stores with sizes averaging 6 metres x 6 metres. In such back stores, there are no formal storage systems but stacking staff knew where to locate the goods due to 'informal systems' established by previous stacking staff. Time to replenish in these neighbourhood stores takes longer due to tight spaces and manual handling of replenishment stock from the back store to the display shelves. Aisle space of these stores is so narrow that shoppers are only provided shopping baskets. Therefore, replenishment of shelves for these stores can only be conducted during off peak periods to minimize aisle congestion. Stores with no back stores placed their excess stock above the display shelves as well as inside the rolling cages, which are rolled out to the back of the store during opening hours and rolled back into the store when closing time is near. One store had a back store that was actually another small disused shed but located 5 minutes' walk away from the store itself. However, the stock is left at the receiving area during wet weather. In such small stores, goods can be easily misplaced by customers, thus causing inaccurate outcomes during visual checks. This is where OS can occur. OS at the stores can also happen when the supermarket chain's private warehouse create warehouse space by offloading stock to the stores.

Most stores of this supermarket chain have small receiving areas with 2 to 3 suppliers arriving every hour. Receipts are conducted with hand-held PDAs. The receiving staff checks the documents submitted by the suppliers and proceed to randomly scan one item from each carton. Cartons containing different canned foods would have to be scanned individually, thus causing lengthy receiving time. Sometimes, a supplier would arrive, go to one corner of the receiving area to quickly affix price tags on each product, such as individual freshly cut fruits. This can cause congestion and error in quantity tagged and received. Such errors are usually undetected until inventory records are tabulated.

Returns i.e. goods unsold or damaged are returned to the respective suppliers or back to the supermarket chain's private warehouse. Documentation and temporary repackaging of returns are performed at the back of the stores. Most stores have designated roller cages for returns while others place returns in plastic containers or hang them onto the sides of roller cages containing replenishment stock. Some stores process their returns immediately while others stipulate a 6 pm processing time on a daily basis. Information pertaining to returns are updated immediately in the stores' systems. Most suppliers update their records within the same day as well but instances where it's not done, suppliers can oversupply, thus causing overstocking at the affected stores.

Another factor that caused OOS and OS in the stores were the configurations of packaging not registered in their information systems. For example, a customer buys five packets of different flavoured instant jelly mixes. The packaging for all flavours is the same except for a round sticker with a diameter of 1.5cm that indicates the flavours located at the top right corner on the packet. Cashier scans one packet and multiplies by five. This causes an error because the customer did not buy five packets of the same flavour thus, resulting in an error to that product's inventory records. Another product commonly mentioned during the interviews, that experienced similar errors were canned drinks, for example carbonated flavoured drinks and beer. Ordering and receiving of canned drinks are done using the item barcode printed on each can. However, promotions of bulk buying are regularly not updated in the system. To exacerbate the problem, canned drinks are sold in different forms. For example, they can be sold as a single can, in a carton of 6, 12 or 24. Each type of packaging configuration has a barcode indicating the packaging size and price. These barcodes are used in ordering and receiving as well. But error occurs when a customer who wants to buy a carton of 6 cans, finds the respecting shelf empty, and then goes to the loose cans, picks up six and becomes annoyed when the system does not offer the discount given to a carton of six being purchased.

Sale of fresh meat, vegetables and fruits are also very difficult to monitor as the stock are received in terms of weight. For example, the entire carcass of a pig is normally delivered to the stores, where they are then cut into pieces, wrapped with foam tray, shrink wrapped and sold. Although the price tag lists the price, date, weight and a bar code, the PoS system only scans the price and not the weight of the packed food. Therefore, OS of these food groups is common. Unsold stock is normally discounted and old stock at closing time is normally discarded.

Related to the previous cause of OOS and OS in stores is the problem of user interface. While standard training has been provided to all users of the information technology and management systems used in the supermarket chain, errors still emerged due to the work attitude of the staff, especially during peak periods, where lines at the checkout stations can be very long. During rush hours, if a mistake was made at the checkout station, it is the cashiers' responsibility to correct the mistake on the system and quickly resume processing purchases. But this 'process' has not been adhered to by staff in certain outlets due to unfamiliarity of the system and also due to pressure to reduce queue time at the checkout stations. Therefore, such errors affect the integrity of information captured by PoS and inventory forecasting.

Supplier performance and deliveries were also affecting OSA of products in stores. Under and over packing of cartons, incorrect barcodes, incorrect deliveries and documentation were commonly cited by managers as poor supplier performance. Error also occurred when suppliers send incorrect orders to the stores, only to realise the mistake was due to the suppliers haven't updated the information on their systems. Senior management has stipulated penalties to address problems with supplier performance in packaging and deliveries. However, penalties are normally not applied as suppliers tend to rush the correct deliveries within the same day so that they can get their delivery documents submitted on time to their offices.

Other factors mentioned at the interviews that caused errors in inventory management of the stores were pilferage, misplacement of goods and write offs. All stores encounter regular pilferage of loose items, such as chilli and grapes. In other instances, 'professional' thieves (termed by store managers) would pay for their purchases but walk back into the store and put unpaid items into their shopping bags. To minimise pilferage, management has resorted to rewarding staff that 'catches' the culprits. Therefore, all staff working on the floor would perform their duties and at the same time, look out for suspicious characters. Misplacement of goods is where stocks are found in the 'wrong' places, such as a bag of mince pork found amongst instant noodles or a bottle of shampoo amongst bottles of cooking oil. Stacking staff, supervisors and store managers are tasked to locate misplaced items and re-stack them to their respective shelves but such an initiative is only effective in the smaller stores. Damaged good such as an opened tetra pack drink cannot be sold and have to be written off. Sale of fresh durians has the highest risk of being written off because customer can choose unopened durians, and then not buy them as opened durians fail on-the-spot taste tests.

Conclusion

The mass grocery supermarket industry is intensively competitive in Singapore. Not only do customers enjoy a plethora of products and good customer service, they also enjoy high levels of choice on where they wish to shop for groceries. Therefore, supermarkets in Singapore must not only contend with product proliferation but they also need to focus on in-store processes to ensure sustainable OSA of stock. This research has shown such challenges faced by one supermarket chain in Singapore. One of the main problems highlighted in Kotzab and Teller (2005) research was "lack of knowledge on cost and service levels of day-to-day works" i.e. what is the cost per item or per carton managed? Discussions with senior management and store managers of this supermarket chain have revealed that such costing are currently not done but will be done in the near future.

Information technology and management in the form of adoption of PDAs, PoS, and ERP systems were implemented to improve data capture, process and inventory visibility to their warehouse, stores and suppliers. However, results have shown that while the technologies were relevant, some of the system users did not embrace the opportunities presented by the systems. Social cognitive theory relates that users of technology needs to obtain self-efficacy, personal outcomes (not performance-based) and expected outcomes to reduce affect, anxiety and therefore be more willing to use the technology (Compeau, Higgins & Huff 1999). Management of this supermarket chain uses performance-based remuneration on the operating staff. Therefore, the ability to use technology and systems in the stores with confidence is somewhat reflected in the quality of performance. Computer training has been provided to all users however, management should look at these staff's individual level of competence and needs instead of having a standard computer training program and remuneration system.

Pilferage of loose items can be minimized if majority of the products, such as chilli, vegetables and fresh fruits are to be packed in clear and porous plastic bags. In this way, the packaging can maintain freshness of the contents (free from human handling) and a deterrent to "habitual thieves" (labelled by the store managers).

This research results can be enhanced if there are opportunities to spend longer time at each activity that takes place in the store as well as interviewing all in-store staff. This will permit a more in-depth understanding into the execution of each activity, to be able to identify areas where lapses in procedures adherence occur and cause(s) of lapses. In addition, follow-up visits to the supermarket chain's senior management to understanding how the costs of OOS and OS events are calculated could shed light on ways to minimize the occurrences of both events. The value of goods that experience OOS and OS should also be studied because findings in this research have revealed that some stores who reported high OOS cost was due to high levels of OOS expensive products versus cheaper products.

REFERENCES

Aastrup, J & Kotzab, H 2010, 'Forty years of Out-of-Stock research - and shelves are still empty', *International Review of Retail, Distribution & Consumer Research*, vol. 20, pp. 147-64.

Abu-Shalback Zid, L 2004, 'When less is more', *Marketing Management*, vol. 13, no. 1, pp. 4-.

Anderson, ET, Fitzsimons, GJ & Simester, D 2006, 'Measuring and Mitigating the Costs of Stockouts', *Management Science*, vol. 52, no. 11, pp. vi-vi.

BMI 2010, *Singapore Food & Drink Report Q3 2010*, Business Monitor International.

Campo, K, Gijsbrechts, E & Nisol, P 2000, 'Towards Understanding Consumer Response to Stock-Outs', *Journal of Retailing*, vol. 76, p. 219.

Chandra, C & Kumar, S 2001, 'Taxonomy OfI nventory Policies For Supply Chain Effectiveness', *International Journal of Retail & Distribution Management*, vol. 29, no. 4, pp. 164-75.

Chopra, S & Meindl, P 2007, *Supply chain management: strategy, planning, and operation*, 3rd edn, Upper Saddle River, N.J. : Pearson/Prentice Hall, c2007.

Clark, K 2004, 'It's in the Data: HEB Fights Out-of-Stocks', *Chain Store Age*, vol. 80, no. 6, pp. 47-8.

Compeau, D, Higgins, C & Huff, S 1999, 'Social Cognitive Theory and Individual Reactions to Computing Technology: A Longitudinal Study', *MIS Quarterly*, vol. 23, no. 2, pp. 145-58.

Corsten, D & Gruen, T 2003, 'Desperately seeking shelf availability: an examination of the extent, the causes, and the efforts to address retail out-of-stocks', *International Journal of Retail & Distribution Management*, vol. 31, no. 12, pp. 605-17.

Department of Statistics Singapore 2011, *Statistics of Singapore*, viewed 09/04/2011 <http://bit.ly/3aLHkP>.

ECR Europe, B 2005, *The Case for ECR - A review and outlook of continous ECR adoption in Western Europe*.

Emmelhainz, LW, Emmelhainz, MA & Stock, JR 1991, 'Logistics Implications Of Retail Stockouts', *Journal of Business Logistics*, vol. 12, no. 2, pp. 129-42.

Fernie, J & Grant, DB 2008, 'On-shelf availability: the case of a UK grocery retailer', *International Journal of Logistics Management*, vol. 19, pp. 293-308.

Rocket Science Retailing Is Almost Here: Are You Ready? 2000, Article. Distributed by Harvard Business School Publication Corp.

Goswami, P & Mishra, MS 2009, 'Would Indian consumers move from kirana stores to organized retailers when shopping for groceries?', *Asia Pacific Journal of Marketing and Logistics*, vol. 21, no. 1, pp. 127-43.

Grant, D 2004, 'UK and US management styles in logistics: different strokes for different folks?', *International Journal of Logistics: Research & Applications*, vol. 7, pp. 181-97.

Grant, DB & Fernie, J 2008, 'Exploring out-of-stock and on-shelf availability in non-grocery, high street retailing', *International Journal of Retail & Distribution Management*, vol. 36, pp. 661-72.

Gruen, TW & Corsten, D 2007, *A Comprehensive Guide To Retail Out-Of-Stock Reduction In the Fast Moving Consumer Goods Industry*. <http://bit.ly/iwN9Xp>

Hariga, MA, Al-Ahmari, A & Mohamed, A-RA 2007, 'A joint optimisation model for inventory replenishment, product assortment, shelf space and display area allocation decisions', *European Journal of Operational Research*, vol. 181, no. 1, pp. 239-51.

Hausruckinger, G 2004, 'Approaches to measuring on-shelf availability at the point of sale', <http://bit.ly/mUKR3o>.
Hausruckinger, G & Hasse, F 2003, 'Rooting out-of-stocks', *ECR Journal*, vol. 3, no. 1, pp. 69 - 71.
Kotzab, H & Teller, C 2005, 'Development and empirical test of a grocery retail instore logistics model', *British Food Journal*, vol. 107, no. 8, pp. 594-605.
Lowson, RH 2001, 'Customized operational strategies for retailers in fast-moving consumer industries', *The International Review of Retail, Distribution and Consumer Research*, vol. 11, no. 2, pp. 201-24.
McKinnon, AC, Mendes, D & Nababteh, M 2007, 'In-store logistics: an analysis of on-shelf availability and stockout responses for three product groups', *International Journal of Logistics: Research and Applications*, vol. 10, no. 3, pp. 251-68.
Messinger, PR & Narasimhan, C 1997, 'A model of retail formats based on consumers'economizing on shopping time', *Marketing Science*, vol. 16, no. 1, p. 1.
Miranda, MJ, Kónya, L & Havrila, I 2005, 'Shoppers' satisfaction levels are not the only key to store loyalty', *Marketing Intelligence & Planning*, vol. 23, no. 2, pp. 220-32.
Svensson, G 2002, 'Effficient consumer response--its origin and evolution in the history of marketing', *Management Decision*, vol. 40, no. 5/6, p. 508.
Trautrims, A, Grant, D, Fernie, J & Harrison, T 2009, *Optimizing On-shelf Availability For Customer Service And Profit*, All Business - A D&B Company, viewed 20 January 2011, <http://bit.ly/l8Sc18>.
Uusitalo, O 2001, 'Consumer perceptions of grocery retail formats and brands', *International Journal of Retail & Distribution Management*, vol. 29, no. 5, p. 214.

SPARE PARTS INVENTORY MANAGEMENT. A LITERATURE REVIEW AND DIRECTIONS FOR FUTURE RESEARCH

Federico Adrodegari, Andrea Bacchetti, Nicola Saccani
Supply Chain & Service Management Research Centre - University of Brescia, Italy
Aris Syntetos
Salford Business School - University of Salford, United Kingdom

ABSTRACT
In industrial contexts the proportion of the stock range that is devoted to spare parts is often considerable (e.g. Vereecke and Verstraeten, 1994) and small improvements in spare parts management may be translated to substantial cost savings (Eaves and Kingsman, 2004). Many research projects have considered issues related to the management of spare part inventories, but very few studies have emphasised the need to bring together the current state of knowledge in this area and critically review the relevant research advancements. The aim of this paper is to cover this gap providing a review of the literature currently available in this area and focusing on the main future research challenges.

1. INTRODUCTION

Service parts for products like household appliances, automobiles and copy machines has grown into a business worth more than a $200 billion worldwide (Gallagher et al., 2005). Spare parts inventories need to be available at appropriate points within the supply chain, to provide after-sales services and to guarantee the desired service level (Botter and Fortuin, 2000). However, several aspects concur in making demand and inventory management for spare parts a complex matter (Cohen et al., 2006): the high number of parts managed; the presence of intermittent or lumpy demand patterns; the high responsiveness required by customers due to downtime cost; and the risk of stock obsolescence.

In industrial contexts the proportion of the stock range that is devoted to spare parts is often considerable (e.g. Vereecke and Verstraeten, 1994). Despite the infrequent demand occurrence associated with such items and the consequent low contribution to the total turnover of an organization, these slower moving SKUs can constitute up to 60% of the total stock value. Thus, small improvements in their management may be translated to substantial cost savings (Eaves and Kingsman, 2004).

Several challenges have been pointed out, given the complexity and relevance of spare parts management. Boone et al. (2008) suggest that companies often lack a system perspective, suffer the weakness of supply chain relationships and the inaccuracy of demand forecasts. On the other hand, research has often kept a "narrow" approach towards spare parts management, focusing on the modeling aspects and neglecting a broader supply chain perspective (Martin et al., 2010). For this reasons some authors argued of a gap between research and practice in spare parts management (Wagner and Liedermann, 2008).

Many research projects have considered issues related to the management of spare part inventories, but very few studies have emphasised the need to bring together the current state of knowledge in this area and critically review the relevant research advancements. The more recent contribution on this topic is the work conducted by Kennedy et al., 2002. The aim of this paper is provide a comprehensive account of the state-of-the-art of spare parts inventory management; we do so by conducting a review of the literature currently available in this area and focusing on the main future research challenges.
The remaining of the paper is structured as follows: section 2 describes the research aims of the work and the adopted methodology. Section 3 provides firstly a brief analysis of the selected literature in terms of number and type of papers, journals and keywords, focusing also on a time-line evolution of the contributions. Secondly in this section the preliminary findings of the research are described, that are then summarised and discussed in the final section (4), in which important avenues for further research are identified.

2. OBJECTIVES AND SEARCH METHODOLOGY

The aim of this research is to identify and collect the literature currently available on spare parts inventory management, and to provide a critical review, in order to outline a state of the art of this research field, and to point out directions for future research. Preliminary results of the analysis of literature we carried out are presented in the following sections of the paper.

We collected relevant literature in the field of service parts inventory management. In determining the scope of the literature review, the focus has been on articles that deal specifically with spare parts inventory management, or that are more general but easily applicable to spare parts management, because for instance address lumpy demand items. Examples of publications within the scope of this review are Kranenburg and van Houtum (2008) in which the authors define the critical level policies with the aim to exploit the differences in target service levels for spare parts inventory, or Pinçe and Dekker (2011) who discuss an inventory model for slow moving items subject to obsolescence.

Outside the scope of our study are papers dealing exclusively with spare parts demand forecasting or forecasting for stock control, or addressing aspects of spare parts management other to the inventory problem. Examples of publications that are out the scope of this review are those such as Downing et al. (2011) in which the authors analyze the impact of inaccurate forecasting on inventory costs, or Holmström et al. (2010) who focus on rapid manufacturing in the spare parts supply chain.

This study focuses on literature published between 1960 and 2001, even if in the 60's and 70's very few articles on spare parts inventory management were written, while attention has sharply increased in the last two decades.

The search strategy was developed first by identifying the relevant data sources, time frame, and keywords. Initially, a very broad selection was made (starting from an existent database of a previous research carried out by the authors) to cover a diverse range of publications (e.g. scientific articles, conference proceedings, theses, books and trade journals). Collectively, these provided access to a wide variety of sources. The 80 sources initially selected for the research, have been reduced according to these criteria:

1. theses, books and general management journals (e.g. "The Harvard Business Review") were discarded;
2. we included journals bearing an Impact Factor and that are present in the ABS classification[1] in the "Operations and Technology Management" or "Management Operational Research and Science" categories (27 journals were selected);
3. for journals with Impact Factor not present in the ABS categories, we choose them if we found articles on spare parts management during a preliminary search (3 journals were selected);
4. the remaining journals in the initial list were subject to subjective evaluation based on their presence or absence in the ABS categories, the results of the preliminary search and the personal judgment of the authors (8 journals were selected).

Therefore, 38 journals were initially selected for the research, which became 41 in view of the ongoing integration of 3 journals with more articles deemed of interest emerged during the first phase of work.

Then a set of keywords was identified to search through the journals. The keywords were directly associated to the spare parts inventory topic (e.g. service parts, inventory, lumpy demand, intermittent demand, Repairable items, multi-echelon system, Inventory

[1] ABS (the British Association of Business Schools) provides a guide to the range, subject matter and relative quality of journals in which business and management academics might publish the results of their research. The ABS Academic Journal Quality Guide is a hybrid based partly upon peer review, partly upon statistical information relating to citation, and partly upon editorial judgments following from the detailed evaluation of many hundreds of publications over a long period.

Control, *etcetera*). Many of these keywords were combined with "spare parts" or with "inventory" when searching the databases, in order to ensure the relevance of the results to this study. This set was then expanded and refined as appropriate articles were discovered. By searching the chosen databases, using the keywords over the selected time period, a large number of articles were initially found. The first list obtained included about 290 papers. It was edited to remove any duplicate records, and the titles were checked to ensure relevance to the review.

The abstracts of all the remaining articles were checked to assess their suitability for this study. Thus, the initial database was carefully filtered to identify the contributions that were directly relevant to our research: we ended up with 191 papers selected, related to the topic of spare parts inventory management, constituting our final database. Due to this refinement, only 27 of the 41 journals identified are included in the final database. Five relevant contributions coming from conferences or working papers have also been included in the database.

Each paper was then classified in the database according to criteria that enable to capture and cluster the main themes and contributions. Classification criteria are mainly related to the type of article (Modeling or Managerial), the adopted point of view (Maintenance or After-Sales), the type of the inventory model proposed, the objective function (costs or service level related), the relative constraints and the presence of an application (case study, simulation experiment with or without real data from industry). Indeed, for each article, it was noted whether it focused on specific issues such as obsolescence, information sharing or stock location problem.

3. PRELIMINARY FINDINGS

The search strategy previously described generated a database of 191 contributions taken from the 27 different journals, as reported in Table 5.

Journals	**# of papers**	**%**
International Journal of Production Economics	38	20%
European Journal of Operational Research	33	17%
Journal of the Operational Research Society	20	10%
Management Science	17	9%
IIE Transactions	12	6%
Operation Research	9	5%
Computers and Operations Research	6	3%
Journal of Quality in Maintenance Engineering	6	3%
International Journal of Production Research	6	3%
International Journal of Operations & Production Management	5	3%
Computers & Industrial Engineering	4	2%
Omega	4	2%
Reliability Engineering and System Safety	4	2%
Expert Systems with Applications	3	2%
Journal of Manufacturing Technology Management	2	1%
IMA Journal of Management Mathematics	2	1%
Journal of Operations Management	2	1%
Manufacturing & Service Operations Management	2	1%
OR SPECTRUM	2	1%
Production Planning and Control	2	1%
Decision Support System	1	1%
International Journal of Computer Integrated Manufacturing	1	1%
International Journal of Forecasting	1	1%
International Journal of Logistics: Research and Applications	1	1%
International Journal of Physical Distribution & Logistics Management	1	1%
International Journal of Quality & Reliability Management	1	1%
Production and Operations Management	1	1%

No Journals (conference proceedings, working papers)	5	3%

Table 5. List of journals and papers included in the literature review

From Table 1, we can observe that two journals alone (IJPE and EJOR) bear a very important contribution to the literature on spare parts inventory management (71 works). The first five journal in Table 1, moreover, provide altogether 120 papers to our database, accounting for 62% of the total.
Referring to the mentioned ABS classification, 15 journals (82 papers) belong to "Operations and Technology Management" category, 8 (92 papers) to "Operational Research and Management Science" class, while the other 4 (12 papers) are not categorized.
The distribution of the papers by period (decade) shows a strong growth of contributions especially in the recent decades, with a peak in 2000-2010; as a matter of fact we have just 10 papers between 1960 and 1979, 73 in the following 20 years and 89 from 2000 to 2009. The first one and half year of the new decade (2010-2011) seems to maintain this trend with 19 contributions, that testify a growth trend (projecting the data on the new decade we would obtain an increased number of papers compared to the last decade). We can argue that spare parts inventory management is still and increasingly in the research agenda of scholars in Operations Management and Operations Research.

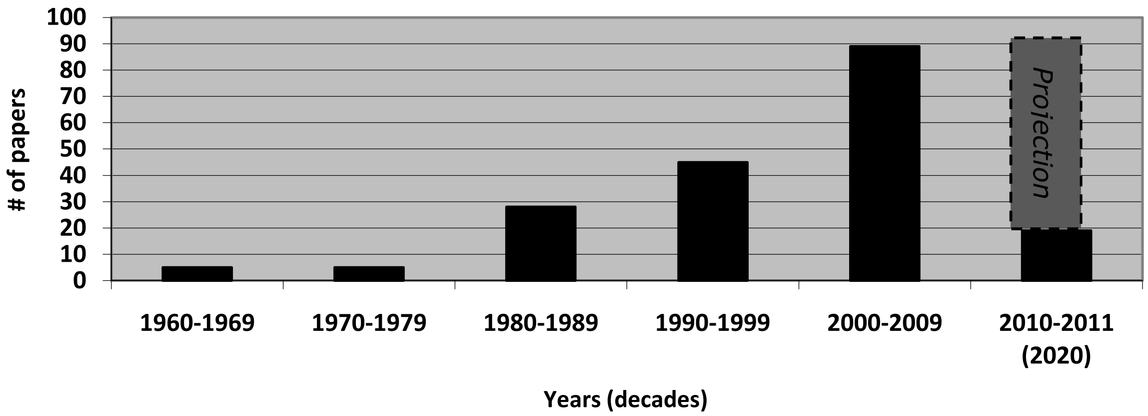


Figure 11. Distribution of papers by decade (including 2010 and 2011 and a projection on the decade 2010-2019)

It is worth of interest to point out the keywords provided in the analysed papers (Table 6).

Keywords	# of occurrences	% occurrences	% of papers
Spare Parts	55	9,5%	36%
Inventory	49	8,5%	32%
Inventory Control	24	4,2%	16%
Maintenance	19	3,3%	13%
Repairable item	9	1,6%	6%
Lateral transhipment	9	1,6%	6%
Optimization	8	1,4%	5%
Heuristics	8	1,4%	5%
Inventory Management	7	1,2%	5%
Multi-echelon	6	1,0%	4%
Inventory Policies	6	1,0%	4%
Forecasting	5	0,9%	3%
Case study	5	0,9%	3%
Obsolescence	5	0,9%	3%
Multi-echelon system	5	0,9%	3%
Supply chain management	4	0,7%	3%
Availability	4	0,7%	3%
Military	4	0,7%	3%
Distribution	4	0,7%	3%

Keywords	# of occurrences	% occurrences	% of papers
Lumpy demand items	4	0,7%	3%
Spare Parts management	4	0,7%	3%
Inventory/production	4	0,7%	3%
Repair capacity	4	0,7%	3%
Others (249)	324	-	-

Table 6. List of the most used keywords in the database

We found 271 different keywords with 576 occurrences on overall. The first 22 keywords (reported in Table 6) appear 252 times, with an incidence of 43,8%. Obviously they are strongly linked with the research stream analysed; as a matter of fact "spare parts", "inventory" and "inventory control" are the most cited keywords. Not surprisingly, "spare parts" is the most widely used keyword. Together with "spare parts management", it is reported in 59 papers (around 39% of the database). However, it appears in less than one third of the reviewed literature, or less than half the 143 works specifically addressing spare parts (see below). This implies that this only keyword would not have been sufficient to carry out a comprehensive literature review. The other most cited ones, "inventory" and "inventory control" are very general, and not of great help since if used alone, they would point to a huge number of papers out of the scope of this research. In the search phase, they have been rather used together with other search keywords. Finally we find out that a part the 22 keywords reported in the database (bearing at least 4 occurrences) other 249 are present in the database, most of them with just one occurrence. This testifies the variety of aspects considered by literature on spare parts inventory management.

Among the 191 selected contributions, 143 are specific for *spare parts* inventory management, while the other 48 deal to inventory management for *intermittent demand items* and so they are applicable to spare parts.

All the analyzed papers are relevant within the wider manufacturing context, referring both to *maintenance* (53 contributions) and *after-sales* (138) operations. We associated with the *maintenance* point of view also the customer's one (e.g. a company that needs to carry out maintenance activities on its own equipment and needs to dimension its spare parts stocks), and to the *After-sales* point of view the manufacturer/supplier's one (e.g. a manufacturer of durable goods that needs to dimension stocks along the distribution network to supply its spare parts customers).

In 54% of cases, papers address repairable spare parts while 36% of contributions consider non repairable spare parts and the last 10% both repairable and non repairable. 59% of the authors investigate a multi echelon scenario, while the other 41% focus on a single echelon supply chain (Figure 12).

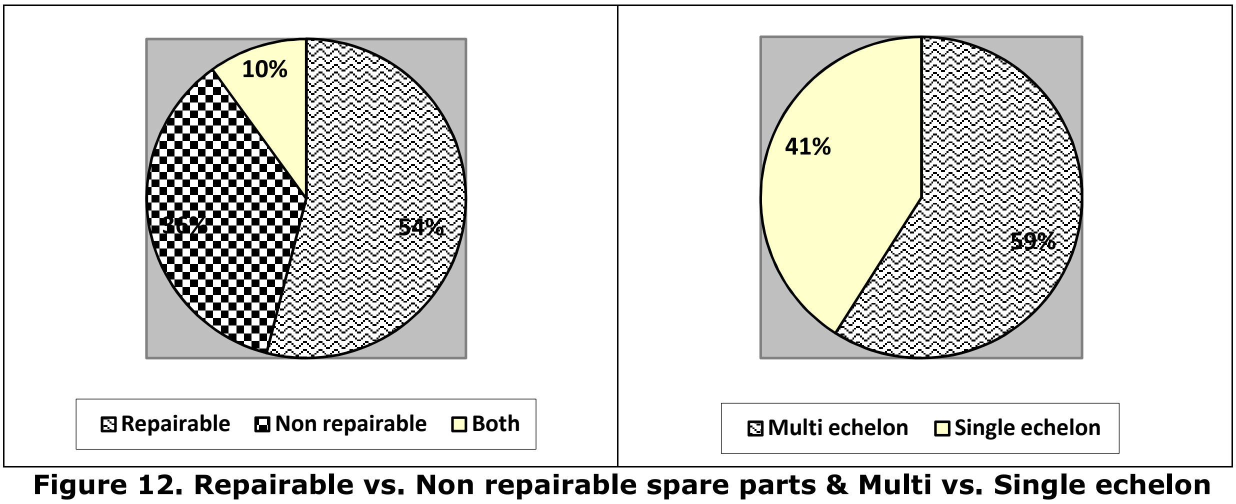


Figure 12. Repairable vs. Non repairable spare parts & Multi vs. Single echelon

127 papers (66%) focus on spare parts inventory management models (we include it in the category "modeling"), while 21 (11%) are "managerial" oriented, because they deal

with management policies without focusing on models but instead proposing guide lines, frameworks or similar. Finally, 43 contributions (23%) refer to both modeling and managerial categories (Figure 13).

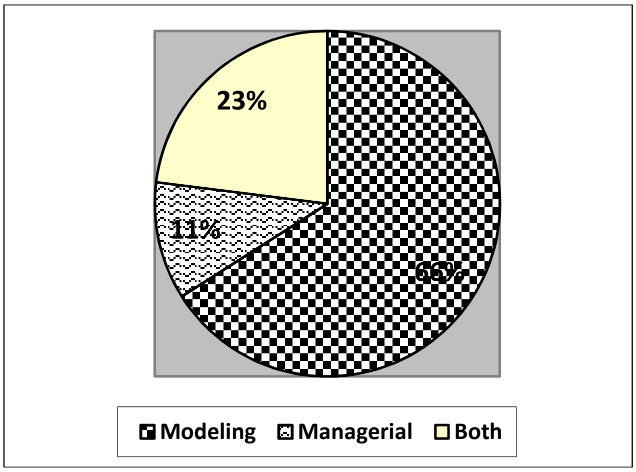


Figure 13. Modeling vs. Managerial contributions

Concerning the modeling papers, in 42% of cases the authors propose a new model for spare parts inventory management, in 43% just an optimization procedure for one or more parameters of a model and in the last 15% of cases we have comparative evaluations among models already proposed in literature.

In the majority of cases (about 85%) models have single objective function, while only the 16% of the contributions work on a multi objective function. In 86% of cases we find an cost/revenue objective function (minimisation of logistics costs or maximisation of profit), while in the other 14% of papers is adopted an objective function related to service level (minimisation of backorders or maximisation of first time fill rate).

In 43% of cases authors do not consider any constraints, while the other 57% of contributions show some constraints, typically related to a target service level to achieve (82%) or to a maximum level of costs to sustain (18%), depending to the objective function defined before.

Almost all the modeling contributions focus on the stock dimensioning problem (*what* and *when* to reorder); in this sense the most adopted and analyzed stock-control policies are:

- the continuous review with an order-up-to level (S) in a one-for-one replenishment mode (S-1, S); 31% of cases
- the continuous review, with fixed re-order point (s) and order-up-to level (S), referred to as (s, S); 19% of cases
- the continuous review, with fixed reorder point (r) and fixed order quantity (Q), referred to as (Q, r); 14% of cases
- the periodic review, with fixed ordering interval (T) and order-up-to level (R), referred to as (T,R); 8 % of cases

Few contributions (36%) consider also the stock allocation problem, in terms of where to place stocks along the supply chain. Interesting to underline that just 24% of the analyzed papers show an application case study of the proposed model, while the others propose a simulation experiment (57%) or nothing (19%).

Indeed, few papers (about 13%) focus on the information sharing issue and its potential impact on the stock control problem; still less (4%) consider the obsolescence phenomena, despite it is for sure a frequent problem in practice.

4. DISCUSSION AND CONCLUSIONS

Although the critical review of the 191 papers in the database has not been completed at the present time, some preliminary observations can be drawn on the descriptive findings provided in the previous section.

First of all, spare parts inventory management is a topic that attracted, in recent years, considerable attention by researchers from the Operations Management and Operations Research fields. In particular, we noticed a concentration of papers in few journals (IJPE, EJOR, JORS, Management Science, IIE Transactions and OR) which are leading the debate on spare parts inventory management.

Since very few works provided a wide literature review on the topic (Guide and Srivastava, 1997; Kennedy et al., 2002) and given the increase in contributions published in the last years (we recorded more than 100 papers between the year 2000 and 2011), we believe that a research effort aimed at an updated categorization of this research stream, as proposed in this paper, can be valuable to the scientific community, and this will be the aim of the completion of the critical review.

One of the main point emerging is that a modelling approach dominates the publishing activity on spare parts inventory management, in line with the OR orientation of most of the journals cited above. This shows the interest in academia in advancing the theoretical knowledge in this field. On the other hand, however, we find a limited number of papers (less than one third) adopting also a managerial approach (i.e. that include a holistic perspective on the spare parts management problem and a practitioner orientation in the application of the proposed method). Empirical applications through case studies, moreover, involve only 24% of the collected literature.

This may be seen as a reason contributing to the research practice-gap encountered in the field of spare parts management, as pointed out by previous works (Wagner and Liedermann, 2008; Boone et al., 2008; Syntetos et al., 2009). Methods presented in research are from one side perceived as too complex by practitioners, or too costly to be put into practice (human resources, systems); on the other hand they are sometimes based on hypotheses that do not take into account all the complexities of a real world setting, ending up in difficult practical applicability or poor performance (Bacchetti and Saccani, 2011). Finally, the organizational perspective within companies is of utmost importance when implementing inventory management systems (Zomerdijk and de Vries, 2003), but despite that it is often neglected by inventory management literature. Based on this comment we identify as an area for future research the extension of the stream of investigation that focuses on aspects that help in “bridging the gap” between research and practice, aimed towards a more widespread adoption on advanced spare parts inventory methods in business practice.

Finally, some gaps pointed out in the previous section suggest further research directions. The obsolescence problem, for instance, is very important in business practice (according to Cohen et al., 2006, 23% of parts become obsolete every year) and companies do often lack methods and tools for dealing with this issue (identification, management and prevention of the obsolescence phenomena). Conversely, only 4% of the contribution in our literature database address this issue, and deserves increased attention. As a second important avenue for research, managing multi-echelon spare parts network in which different actors are involved (parts suppliers, OEMs, distributors and wholesalers, dealers, service shops, *et cetera*) poses certainly a major challenge for excelling in either cost or service performance (or both), from a global supply chain standpoint. The issue of information sharing among different supply chain tiers and players, that can be the basis for improved practice or specific techniques such as Vendor Managed Inventory or Lateral Transhipments, is also under-investigated in literature and can be a promising area for conceptual as well as applied research.

REFERENCES

Bacchetti A., Saccani N., 2011. Spare parts classification and demand forecasting for stock control. Investigating the gap between research and practice, *submitted*

Boone C.A., Craighead C.W., Hanna J.B., 2008. "Critical challenges of inventory management in service parts supply: A Delphi Study", Operations Management Research 1, 31-39.

Botter R., Fortuin L., 2000. Stocking strategy for service parts: a case study, International Journal of Operation and Production Management, 20, 656-674

Cohen M.A. and Agrawal N., 2006. "Winning in the Aftermarket", Harvard Business Review, Vol. 84, No. 5, pp. 129-138

Downing M.P., Chipulu M., Ojiako U., Kaparis K., 2011. Forecasting in airforce supply chains, International Journal of Logistics Management, 22 (1)

Eaves, A., Kingsman, B., 2004. Forecasting for the ordering and stock-holding of spare parts. Journal of the Operational Research Society 55 (4), 431-437.

Gallagher T., Mitchke M.D., Rogers M.D., 2005. Profiting from spare parts, The McKinsey Quarterly

Guide D.R., Srivastava R., 1997. Repairable inventory theory: Models and applications, European Journal of Operational Research, 102, 1-20

Holmström J., Partanen J., Tuomi J., Walter M., 2010. Rapid manufacturing in the spare parts supply chain: Alternative approaches to capacity deployment, Journal of Manufacturing Technology Management, 21 (6), 687 – 697

Kennedy, W.J., Patterson, J.W., and Fredendall, L.D., 2002. An overview of recent literature on spare parts inventories. International Journal of Production Economics, 76 (2), 201–215

Kranenburg A.A., van Houtum J.G., 2008. Service differentiation in spare parts inventory management. Journal of the Operational Research Society, 59, 946–955

Martin H., Syntetos A.A., Parodi A., Polychronakis Y.E., Pintelon L., 2010. Integrating the spare parts supply chain: an inter-disciplinary account, Journal of Manufacturing Technology Management, 21, 226-245

Pinçe Ç. Dekker R., 2011. An inventory model for slow moving items subject to obsolescence, European Journal of Operational Research, 213 (1), 83-95

Syntetos, A.A., Keyes, M., Babai, M.Z., 2009. Demand categorisation in a European spare parts logistics network. International Journal of Operations & Production Management 29, 292-316

Vereecke A., Verstraeten P., 1994. An inventory management model for an inventory consisting of lumpy items, slow movers and fast movers, International Journal of Production Economics, Elsevier, 35, 379-389

Wagner, S. M., Liedermann, E., 2008. A case study-based analysis of spare parts management in the engineering industry, Production Planning & Control, 19, 397 — 407

Zomerdijk, L. and de Vries, J., 2003. An Organizational perspective on inventory control: theory and a case study, International Journal of Production Economics, Vol. 81-82, pp. 173-183

ANALYTIC HIERARCHY PROCESS AND ITS APPLICATIONS IN LOGISTICS RESEARCH

Shams Rahman[1], Nachiappan Subramanian[2], Caroline Chan[3]

[1, 3]School of Business IT & Logistics
RMIT University, Melbourne, Victoria, Australia
Shams.rahman@rmit.edu.au

[2]Department of Mechanical Engineering
Thiagarajar College of Engineering, Madurai, India
spnmech@tce.edu

ABSTRACT

Purpose of this paper

This paper investigates the applications of multi-criteria decision making technique AHP and its variants such as Fuzzy AHP and ANP in Logistics research. The purpose of this study is to systematically review relevant literature in order to identify gaps for future research.

Design/methodology/approach

A systematic search via Emerald, Ingenta, Ebsco, ProQuest, and ScienceDirect identified 51 peer reviewed journal articles published between 2000 and 2010. The identified articles were categorised and analysed using three distinctive aspects of logistics systems such as logistics design, logistics optimisation and logistics management.

Findings

The results of the study indicate that most applications are in logistics management aspect of logistics systems. The number of application of Fuzzy AHP and ANP models were found to be higher in the logistics design aspect compared to optimisation and management aspects. The review also indicates that in spite of its shortcomings the traditional AHP model continues to dominate. Seventy seven per cent of the articles reviewed were found to be traditional AHP with and without integration with other methods. Neither the Fuzzy AHP approach nor the ANP methods were applied to optimise the logistics systems. In general, the review shows that minimal work has been conducted with respect to logistics optimisation. Some of the methods applied in conjunction with AHP and its variants are delphi method, goal programing, TOPSIS method, neural network, gap analysis, linear programming, heuristics, DEMATEL, genetic algorithm, life cycle management approach, and system dynamics and simulation.

Research limitations/implications

The framework for analysis has been developed based on literature review. This research investigates the applications of AHP and its variants in logistics management in general and doesn't look into specific industry or sector.

Practical implications

By identifying areas and types of AHP applications this paper provides a research agenda to guide future research.

What is original/value of paper

Develops a framework to analyse the application of AHP and its variants for various decision problems in logistics management. The findings guide researchers to focus on important decision areas for AHP application in Logistics management.

Keywords: Analytic hierarchy process, Fuzzy analytic hierarchy process, analytic network process, Logistics research

INTRODUCTION

Analytic hierarchy process (AHP) is a decision-making approach which integrates simultaneously qualitative and quantitative information for prioritizing alternatives when multiple criteria must be considered. Over the last twenty-five years AHP has been widely used to solve decision problems in areas such as supply chain risks assessment (Schoenherr et al. 2008), 3PL selection (Gol and Catay, 2007); supplier selection (Ghodsypour and O'Brien, 1998; Wang et al. 2004). To understand the nature of the AHP applications surveys were conducted in the past (Vaidya and Kumar, 2006; Steuer and Na, 2003; Ho, 2008). Steuer and Na (2003) reviewed the literature of the applications of AHP in the finance area, whereas, Vaidya and Kumar (2006) explored the use of AHP in areas such as education, engineering, government and sports. However, both these surveys analysed the applications of the stand-alone AHP. Recently, Ho (2008) reviewed the literature of the applications of the integrated AHPs published between 1997 and 2006.

Although AHP is a useful approach for evaluating complex multi-criteria alternatives, there are two major limitations. The first limitation is its assumption of independency among various criteria of decision making which makes it difficult to assess the correlations among criteria. An alternative variant of AHP with 'crossover' effects is the analytic network process (ANP) (Saaty, 1996). Contrary to AHP, ANP provides a more generalised model without making assumptions about the independency of the criteria at different levels of the hierarchy and also of the criteria within a level. The second limitation of AHP is its use of crisp judgments for pair-wise comparisons between criteria. The traditional AHP employs a scale with exact numbers between 1– 9 (Saaty, 1980). Since much decision making involves some uncertainty, the use of fuzzy numbers and linguistic terms is more suitable and a more natural way of dealing with preferences instead of exact values (Ribeiro, 1996). Besides, one of the most important aspects for a useful decision making aid is to provide the ability to handle imprecise and vague information (Zhang et al., 2002). Recently, due to these limitations, the focus has moved from the applications of stand-alone AHP towards the applications of fuzzy AHP and ANP models for decision making. This study reviews the literature of the applications of AHP, fuzzy AHP and ANP in logistics research between 2000 and 2010.

FRAMEWORK FOR REVIEW

The aim of logistics systems is to coordinate the 'forward and reverse flow of materials, services, finance and information from the original producer to final customer with the benefits of adding value, maximising profitability through efficiencies, and achieving customer satisfaction', (Stock and Boyer, 2009, p. 706). It takes into account the design, optimization, and management of the internal and external constituents of logistics systems, including material supply, transformation of materials and distribution of finished products and services to customers, that is consistent with overall objectives (Spekman et al., 1998, Çelebi, 2010). In this study we review the applications of AHP, Fuzzy AHP and ANP for various decisions in design, optimisation and management of logistics systems. The operational definition of each decision making aspect of logistics systems are given below:

Logistics design: design in general is viewed as conceiving the product/service and drawing up the specifications (Chase and Aquilano, 1985). We view application of AHP, fuzzy-AHP and ANP in design of logistics such as supply of material and services, transformation of product and distribution.

Logistics Optimisation: Optimisation in general is to select the best option under given set of constraints. We view application of AHP, Fuzzy AHP and ANP in optimisation of logistics such as supply of material and services, transformation of product and distribution.

Logistics Management: encompass all activities such as supply of material and services, transformation of product and distribution. Table 1 shows key elements within each decision making aspect of logistics systems.

Aspect of logistics

	Keys elements
Design of logistics systems	Supplier selection and order quantity determination, selection of plant/warehouse location, evaluation of alternate logistics strategies, outsourcing, outsourcing non-core assets and competences, identifying successful new ventures, decisions on procurement and supply.
Optimisation of logistics systems	Modelling of global logistics, framework for selecting suitable ERP system, evaluation of business process outsourcing (BPO), evaluation of web-based decision support system for service contracts, evaluating sources of supply, ranking suppliers based on risk, inbound supply risk analysis, evaluating and selecting e-commerce software, vendor rating, logistics evaluation.
Management of logistics systems	Classification and management of spare parts inventory, software metrics, customer satisfaction, key success factors for strategic outsourcing, internet retailing, website quality on e-business success.

Table 1: Key elements within three aspects of logistics systems

ANALYSIS AND RESULTS

A systematic search via Emerald, Ingenta, Ebsco, ProQuest, and ScienceDirect identified 51 peer reviewed journal articles published between 2000 and 2010. The result shows that over 42% of the papers were published in four journals such as International Journal of Production Economics, European Journal of Operational Research, Omega: The International Journal of Management Science, and Computers & Industrial Engineering. The distribution of papers in three aspects of logistics systems along with the study purpose, criteria considered for evaluating alternatives and methods employed for integrated application are given in Table 2 – 4.

Reference	Study purpose	Criteria considered	Methods for integrated application
AHP application			
Alberto (2000)	select appropriate location	time reliability of delivery, response flexibility and capability of operations integration	
Tam and Tummala (2001)	select the vendor of a telecommunications system	cost and quality aspects	
Wei et al. (2005)	selecting a suitable Enterprise Resource Planning (ERP) system	Total cost, implementation time, functionality, user friendly interfaces and operations, flexibility, reliability, reputation, technical capability and service	
Yan et al. (2008)	effectively select partners participating in a collaborative design and bidding process	Internal features, external features and accessories	Neural network
Presley et al. (2007)	Design and development of the strategic sustainability evaluation framework	Economic (NPV), delivery performance, supply chain cycle time), Environmental (Waste generated, improved compliance, per cent of product reclaimed), Social (Internal human resources, external population, stakeholder participation)	
Fuzzy-AHP application			
Lin (2009)	Identify the key factors of RFID technology development in logistics	Cost, technology, infrastructure, international standard and specification, security and privacy	Fuzzy-Delphi
ANP applications			
Ravi et al. (2005)	Analyse alternatives in	Economic factors, legislation, corporate	Balanced score

	reverse logistics for end of life computers	citizenship, environment and green issues	card approach
Jharkhariaa and Ravi Shankar (2007)	Selection of logistics service provider	Compatibility, cost, quality, reputation	
Ravi et al. (2008)	Selection of reverse logistics project for end-of-life computers	Increase use of resource reduction, increase of eco efficiency, development of green products, cost of implementation of reverse logistics programs	Goal programming
Efendigil et al (2008)	Select most appropriate third party reverse logistics provider	On-time delivery, confirmed fill rate, service quality level, unit operation cost, capacity usage rate, total order cycle time, system flexibility index, integration level index, increment in market share, research and development ratio, environmental expenditures, customer satisfaction index	
Wu et al. (2009)	Selection of suitable partner for strategic alliance	Characteristics of the partner, degree of fitness, intangible assets, marketing knowledge capability, complimentary capabilities	
Büyüközkan and Öztürkcan (2010)	Determine critical six sigma project in logistics industry	Business excellence, revenue growth, productivity	DEMATEL

Table 2: AHP, Fuzzy AHP and ANP applications in Logistics design

Reference	**Main purpose of the study**	**Criteria considered**	**Methods for integrated application**
AHP application			
Korpela et al. (2001a)	Optimise a company's supply chain based on customer service requirements	Profitability, partnership, volume and financial viability	Mixed integer programming
Chan (2003)	supplier selection problem under dynamic supply chain system	Cost, quality and design	
Wang et al. (2004)	supplier selection and determine the optimal order quantity	Delivery reliability, flexibility and responsiveness, cost and assets	Goal Programming
Sarkis and Talluri (2004)	select best e-Commerce software for the supply chain	Adaptability, openness, scalability, security, reliability, ease of use, support, perceived value, speed standard compliance, cost, filtering, information access and service	Goal programming
Percin (2006)	supplier selection and order quantity allocation	Manufacturing, technology, business and service	Goal programming
Xia and Wu (2007)	determine the set of suppliers and order quantities	Price, quality and service	Rough set theory and multi objective integer programming
Rabelo et al (2007)	maximization of shareholder value of global supply chain of a multinational construction equipment corporation	Profitability, responsiveness, customer satisfaction, political stability	System dynamics and simulation
Chen and Huang (2007)	determine potential suppliers by matching product characteristics with supplier characteristics	Asset, business criteria, cost and delivery	Bi-negotiation agents

Tsai and Hung (2009)	auction revenue management in Internet retailing	Excess demand growth, market share, life cycle, threat of new products and long term return volatility ratio	Real options approach

Table 3: AHP, Fuzzy AHP and ANP applications in Logistics optimisation

Reference	Study purpose	Criteria considered	Methods for integrated application
AHP application			
Masella and Rangone (2000)	Propose four different vendor selection systems	time frame and on the content of the cooperative customer/supplier relationships	
Korpela et al. (2001b)	supply chain development	Reliability, flexibility and relationship	PROPER approach
Bhutta and Huq (2002)	supplier selection	Manufacturing, quality costs, technology and after sales service	TCO
Handfield et al. (2002)	evaluate the relative importance of various environmental traits and to assess the relative performance of several suppliers	Product attribute, waste management, labelling / certification, packing / reverse logistics, compliance to government regulations and environmental programs at suppliers facilities	Delphi technique
Lee and Kozar (2006)	asses the website quality of B2C retail websites	Information quality, system quality, service quality and vendor specific quality	
Wu et al. (2006)	classify, manage and asses inbound supply risk	Internal and external risks (controllable, partially controllable and uncontrollable)	
Gaudenzi and Borghesi (2006)	assess risk in supply chain	On-time delivery, completeness, correctness and damage-defect free	
Korhonen and Voutilainen (2006),	Evaluated most preferred alliance between banks and insurance companies (M)	Product development, one-door principle, earnings logics, customer relationship management, cost and revenue synergies, channel conflicts, required solvency capital, investor power and sales management	
Brent et al. (2007)	minimise infection in health care systems	Container, infrastructure, procedures	Life cycle management approach
Levary (2007)	rank the foreign suppliers based on supply risk	supplier reliability, country risk, transportation reliability, reliability of supplier's supplier	
Baramichai et al. (2007)	agile capability creation for supplier-buyer supply chain configuration and supplier-buyer relationship establishment and determine the business processes and the infrastructures needed	Implementation cost, risk and applicability	QFD
Sharma and Bhagwat (2007)	supply chain management evaluation	Finance, customer, internal business process, and learning and growth	Balanced score card
Bhagwat and Sharma (2007)	making SCM evaluation decisions	Strategic, tactical and operational	Balanced score card
Udo (2000)	IT outsourcing decision	Strategic importance, stakeholder interest, vendor issues, cost operations, industry environment	
Akarte et al. (2001)	casting supplier assessment	Product development capability, manufacturing capability, quality capability and cost and delivery	
Lai et al. (2002)	selection of multimedia authorising system (MAS)	development interface, graphics support, multimedia support, data file support, cost effectiveness and vendor support	
Sundarraj (2004)	Managing and supporting service contracts (M)	Customer related, contract related and product related	Heuristics approach
Yoon and Im	evaluating system of the	service satisfaction, customer	

(2005)	IT customer satisfaction	supporting service satisfaction and performance satisfaction.	
Sureshchandar and Leisten (2006)	examine the relative importance of software metrics	Product, process and resource categories	
Hafeez et al. (2007)	evaluating the firm assets and competences	marketing knowledge, design skills, manufacturing skills and customer relationship	
Yang et al. (2007)	identify the factors that affect a Business Process Outsourcing (BPO)	Expectation, environment and risk	Statistical method
Wang and Yang (2007)	enrichment evaluation for information system outsourcing decision	factors economics, resource, strategy, risk, management and quality	Preference ranking
Chan and Chin (2007)	identify and examine the importance of the key success factors of strategic sourcing	visionary leadership in strategic sourcing, supplier management system and continuous improvement	Statistical method
Botter and Fortuin (2000)	Evaluation of criticality of spare parts inventory	Response time, life cycle, demand, purchase lead time, price	VED approach
Braglia et al. (2004)	Classify and effectively manage spare parts inventory	Plant criticality (quality problems, production loss, environmental and safety aspects) , Supply (Masked time, cannibalism, lead time, number of potential suppliers, internal repair) Inventory (price, space, obsolescence, deterioration) and usage rate (identical parts, redundancies and failure)	Reliability centred maintenance (RCM)
Fuzzy-AHP applications			
Sheu (2004)	Identify global logistics strategies	Management control, core competitiveness, business operational orientation, marketing and service, response to external environments	Fuzzy Multi attribute decision making
Sheu (2008)	Identify appropriate global logistics operational modes	Management control, core competitiveness, Trans-organisational coordination, marketing and service, overseas resource availability, environmental variability	Neural network and TOPSIS
Buyukozkan et al. (2008)	Provide a decision support to make a careful assessment of e-logistics partner	Strategic dimension (similar value-gaols, similar size, financial stability, comparable culture, successful track record, sustainable relationship) and business excellence (technical expertise, performance, market knowledge, managerial experience)	TOPSIS
ANP applications			
Partovi (2006)	Facility location decision	customer wants, status of competition, characteristics of location and critical internal processes	QFD
Celebi et al. (2010)	Determine best logistics partnership strategy of small electronic appliances manufacturer operating in Turkey	On-time delivery, accurate delivery, service network, Investment cost, transportation cost, inventory service cost, logistics information system, information sharing and communication network, adaptation to technological development	

Table 4: AHP, Fuzzy AHP and ANP applications in Logistics management

Out of fifty one articles reviewed, twelve (25%) were applied in the design of logistics systems, nine papers (about 17%) were applied for the optimisation of logistics systems and 30 papers (58%) were applied in the management of logistics systems.

DISCUSSION

The results of the study indicate that most applications were in logistics management (over 58%) compared to design (25%) and optimisation (approx. 17%) domains of logistics systems. The number of applications of Fuzzy AHP and ANP models was relatively higher in logistics design compared to optimisation and management aspects of logistics. The review also indicates that in spite of its shortcomings the traditional AHP model continues to dominate. Seventy seven per cent of the articles reviewed were found to be traditional AHP with and without integration with other methods. Neither the Fuzzy AHP approach nor the ANP method were applied to optimise the logistics systems. In general, the review shows that minimal work has been carried out with respect to logistics optimisation. Some of the methods applied in conjunction with AHP and its variants are delphi method, goal programing, TOPSIS method, neural network, gap analysis, linear programming, heuristics, DEMATEL, genetic algorithm, life cycle management approach, and system dynamics and simulation. The analysis indicates that most of the applications of AHP and its variants were in the area of supplier selection. Although the issue of interdependency in the design aspect of logistics systems were addressed, however, very little attention were given to account for uncertainty and interdependency in management and optimisation aspects of logistics systems.

CONCLUSIONS

This study systematically reviews the literature to identify the applications of AHP, Fuzzy AHP and ANP models in logistics over the last decade. It assesses the distribution of applications in three aspects of logistics systems such as logistics design, logistics optimisation and logistics management. The results of the review indicate that in spite of its significant shortcomings, the traditional AHP model continues to be applied more frequently than Fuzzy AHP and ANP. The review also indicates that most applications are within the management aspect of logistics systems compared to design and optimisation aspects. To address the uncertainty and dependency issues in the areas of design, optimisation and management of logistics systems more research using Fuzzy AHP and ANP is required.

REFERENCE

Akarte. MM, Surendra. NV, Ravi. B and Rangaraj. N (2001), Web based casting supplier evaluation using analytical hierarchy process, Journal of the Operational Research Society, Vol. 52, pp. 511-522.

Alberto, P, (2000), "The Logistics of Industrial Location Decisions: An Application of the Analytic Hierarchy Process Methodology", International Journal of Logistics: Research and Applications, Vol. 3, No. 3, pp. 273-289.

Barker, T.J., Zabinsky, Z.B. (2011) A multi criteria decision making model for reverse logistics using analytical hierarchy process. Omega 39, 558–573

Baramichai.M, Zimmers Jr. E.W. and Marangos. C A. (2007), Agile supply chain transformation matrix: an integrated tool for creating an agile enterprise, Supply Chain Management: An International Journal, Vol. 12, No. 5, pp. 334–348.

Braglia, M., Grassi, A and Montanari, R (2004), "Multi-attribute classification method for spare parts inventory management", Journal of Quality in Maintenance Engineering, Vol 10, No. 1, pp. 55-65.

Botter. R and Fortuin. L. (2000) Stocking strategy for service parts - a case study, International Journal of Operations & Production Management, Vol. 20 No. 6, pp. 656-674.

Büyüközkan,G and Öztürkcan, D (2010), An integrated analytic approach for Six Sigma project selection, Expert Systems with Applications 37 (2010) 5835–5847

Brent, A.C, Rogers, D.E.C, Ramabitsa-Siimane, T.S.M and Rohwer, M.B (2007), "Application of the analytical hierarchy process to establish health care waste management systems that minimise infection risks in developing countries", European Journal of Operational Research Vol. 181, pp. 403–424.

Bhagwat, R. and Sharma, M. K.(2007) 'Performance measurement of supply chain management using the analytical hierarchy process', Production Planning & Control, Vol.18, No.8, pp.666 - 680.

Bhutta, K.S. and Huq, F., (2002), "Supplier Selection Problem: A comparison of the total cost of ownership and analytic hierarchy process approaches", Supply Chain Management: An international Journal, Vol. 7, No.3, pp. 126-135.

Buyukozkan,G., Feyzioglu,O., Nebol,E. (2008), Selection of the strategic alliance partner in logistics value chain, Int. J. Production Economics 113, 148–158.

Çelebi, D, Bayraktar,D., Bingöl,L., (2010), Analytical Network Process for logistics management: A case study in a small electronic appliances manufacturer, Computers & Industrial Engineering 58 (2010) 432–441

Chan.F.T.S (2003) Interactive selection model for supplier selection process: an analytical hierarchy process approach, Int. J. Prod. Res., Vol. 41, No. 15, pp. 3549–3579.

Chan,T.C.T and Chin,K.S. (2007), Key success factors of strategic sourcing An empirical study of the Hong Kong toy industry, Industrial Management & Data Systems, Vol. 107, No. 9, pp. 1391-1416.

Chase, R.B. and Aquilano, N.J, (1985), "Production and Operations Management: A life cycle approach", Richard D.Irwin, INC., Homewood, Illinois.

Chen, Y and Huang, P, (2007), "Bi-negotiation integrated AHP in suppliers selection", Benchmarking: An International Journal Vol. 14, No. 5, pp. 575-593.

Efendigil, T., Onut, S., Kongar,E., (2008), A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness, Computers & Industrial Engineering 54, 269–287

Forman, E., Gass, S.I., (2001), The analytic hierarchy process: An exposition. Operations Research, Vol. 49, No. 4, pp. 469–486.

Gaudenzi, B and Borghesi,A, (2006), "Managing risks in the supply chain using the AHP method", The International Journal of Logistics Management Vol. 17, No. 1, pp. 114-136.

Gol, H and Catay, B (2007), Third party logistics provider selection: insights from a Turkish automotive company, Supply Chain Management: An International Journal, 12, 6, 379-384.

Hafeez,K, Malak, N., Zhangc, Y.B (2007), "Outsourcing non-core assets and competences of a firm using analytic hierarchy process", Computers & Operations Research, Vol. 34, pp.3592 – 3608

Handfield, R. B., & Nichols, E. L. (1999). Introduction to supply chain management. N.J.: Prentice Hall.

Handfield, R., Walton,S.V., Sroufe,R. and Melnyk.S.A (2002), Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process, European Journal of Operational Research, Vol. 141, pp. 70–87.

Huang, C-C, Chu, P-Y and Chiang, Y-H (2008), A fuzzy AHP application in government-sponsored R&D project selection, Omega – The International Journal of Management Science, 36, 1038-1052.

Jharkhariaa, S. Ravi Shankar (2007), Selection of logistics service provider: An analytic network process (ANP) approach, Omega 35, 274 – 289.

Korhonen, P and Wallenius, J (1990), Using qualitative data in multiple objective linear programming, European Journal of Operational Research, Vol. 48, pp. 81-87.

Korpela. J, Lehmusvaara.A, Tuominen.M , (2001), Customer service based design of the supply chain, Int. J. Production Economics Vol. 69, pp.193-204.

Korpela. J, Lehmusvaara. A and Tuominen. M (2001), An analytic approach to supply chain development, Int. J. Production Economics, Vol. 71, pp. 145-155.

Lai.V.S., Wong.B.K. and Cheung.W. (2002), Group decision making in a multiple criteria environment: A case using the AHP in software selection, European Journal of Operational Research, Vol.137, pp.134-144.

Lee, Y and Kozar, K.A (2006), "Investigating the effect of website quality on e-business success: An analytic hierarchy process (AHP) approach", Decision Support Systems, Vol. 42, pp.1383–1401.

Levary, R.R., (2007), Ranking foreign suppliers based on supply risk", Supply Chain Management: An International Journal, Vol. 12, No.6, pp. 392–394.

Lin, L.C., (2009), An integrated framework for the development of radio frequency identification technology in the logistics and supply chain management, Computers & Industrial Engineering 57 (2009) 832–842.

Masella and Rangone. A., (2000) contingent approach to the design of vendor selection systems for different types of co-operative customer/ supplier relationships, International Journal of Operations and Production Management, Vol.20, No.1, pp.70-84.

Ozgen, A, Tanya,M. (2011), Joint selection of customs broker agencies and international road transportation firms by a fuzzy analytic network process approach, Expert Systems with Applications 38 (2011) 8251–8258.

Partovi, F.Y (2006), "An analytic model for locating facilities strategically", Omega, Vol. 34, pp.41 – 55.

SUPPORT OF AN OPERATIONAL SUPPLY CHAIN RISK MANAGEMENT FOR SENSITIVE LOGISTICS NODES

C Breuer, H-D Haasis**, M Plöger**, G Siestrup*, H Wildebrand***

*Hochschule Furtwangen University, Faculty of Business Information Systems
Robert-Gerwig-Platz 1, 78120 Furtwangen, Germany
E-Mail: Claudia.Breuer@hs-furtwangen.de, Guido.Siestrup@hs-furtwangen.de

**Institute of Shipping Economics and Logistics (ISL),
Universitätsallee 11-13, 28359 Bremen, Germany
E-Mail: Haasis@isl.org, Ploeger@isl.org, Wildebrand@isl.org

ABSTRACT
The increasing integration of companies, associated with the necessary synchronisation of the logistics processes, lead to a heightened risk potential within the supply chain. As risks cannot be completely avoided, supply chains need to be prepared for the occurrence of damaging events. Therefore knowledge of the underlying logistics processes is essential.

For this purpose we present in this paper a process-driven reference model which builds the base for an operational supply chain risk management. The reference model is specifically aimed at sensitive logistics nodes. These nodes represent spatially aggregated areas where companies of multiple supply chains are united and the proportion of value added by logistics processes is high. If a disruption of the supply chain occurs, the economic damage can be enormous. In this context the process-driven reference model can be of assistance and enables a rapid reaction once a damaging event occurs.

Keywords: supply chain risk management, reference model, sensitive logistics nodes, freight villages

INTRODUCTION
There is a strong awareness for risks in supply chains due to disastrous events like terrorist attacks, natural disasters or widespread disruptions caused for example by fuel protests in the UK and followed by the outbreak of the Foot and Mouth Disease (Jüttner et al. 2003, Peck 2005). Such disasters can lead to an interruption of many supply chains because these are interconnected by structural and geographic aspects. For instance, a company can be integrated in many supply chains and often companies share a common location in so-called industrial agglomerations like logistics centres or logistics parks. These industrial agglomerations are embedded in supply chains to improve delivery and transport times and to support fluent material flows. They can be seen as sensitive logistics nodes because if a damaging event arises, multiple supply chains are concerned. Therefore it is remarkable, that the most discussed measures in literature regarding supply chains are concerned with the prevention and the mitigation of risks while the handling of the impacts of such risks get little attention (see for example Wagner et al. 2007, Ritchie et al. 2009).

Our proposed approach is to develop a concept to support an operational supply chain risk management in sensitive logistics nodes. Our main objective is to maintain business continuity and the resumption of current business. For this purpose we want to (i) achieve transparency of the processes in sensitive logistics nodes, (ii) identify possible risks and (iii) support the decision-making in the context of handling risks.

In this paper, our approach for the first objective, achieving transparency of the processes in sensitive logistics nodes, is shown.

BACKGROUND AND RELATED WORK

The increasing integration of companies, associated with the necessary synchronisation of the logistics processes, lead to a heightened risk potential within the supply chain. If an event occurs with corresponding damages inside the supply chain, these can continue to the next partners and enlarge the economic damage (Jüttner et al. 2003). Due to this cross-company integration, new risk situations arise, which need to be assessed in their entirety (Ritchie et al. 2009).

The importance of risk management in supply chains has been identified: Over the last years, supply chain risk management has gained greater significance, both for users and in the research field, as can be seen in an increasing number of publications on this topic (Buscher et al. 2007). In these publications different approaches to the supply chain risk management are pursued. By way of example the transfer of general perceptions of risk management to the supply chain risk management (Pfohl et al. 2010), but also the integration of a cross-company risk management (Winkler et al. 2007) are discussed. Besides this, many publications are aimed at different strategies for the handling of risks which are risk prevention, risk mitigation, risk sharing and risk acceptance (Kersten et al. 2008). Measures to achieve the intended aims of these strategies can be divided into two types of measures; measures with regard to the causes of risks and measures concerning the impacts of risks. While measures in relation to the causes of risks pursue risk prevention and risk mitigation, measures with regard to the impacts of risks are aimed at the economic consequences of a damaging event and aim at the limitation of possible losses (Wagner et al. 2007). For instance, Chopra and Sodhi (2004) consider the effects of preventing measures in relation to the causes of risks while Zsidisin et al. (2005) also deal with the elaboration of "blueprints" which include the activities to perform, when a disruption occurs. These "blueprints" provide the basis of measures on an operational level.

It should be noted, that the previous research is primarily focused on the strategic level of supply chain risk management: currently existing concepts intend to organise a supply chain so that risks can be prevented or the probability of occurrence of a damaging event can be mitigated (see for example Wagner et al. 2007, Ritchie et al. 2009, Wagner et al. 2010).

As mentioned above, our approach aims at the development of a concept to support the decision-making on an operational level, so that affected companies are prepared and can react rapidly once a damaging event occurs.

METHODOLOGY

For maintaining business continuity and resuming current business in industrial agglomerations the underlying processes must be known. Knowledge of these processes enables the consideration of the relationships between them. Furthermore, bottleneck and synergy effects can be detected and incorporated into decision-making (Haasis 2008). Also, this knowledge allows an intervention at the operational level, helping us to sustain critical business activities (Romeike et al. 2003).

To capture these processes and achieve transparency of them, a process-driven reference model for sensitive logistics nodes is created. For the construction of this reference model, the consideration of existing reference models is useful. Particularly the Supply Chain Operations Reference Model (SCOR-Model), which has become an established standard in the logistical context, is considered. The adaption of this reference model to industrial agglomerations like sensitive logistics nodes requires significant changes. The SCOR-Model supports the processes along the supply chain with the main processes plan, source, make, deliver and return (Poluha 2010). These are all activities which can be found in industrial agglomerations, which represent spatially aggregated facilities where the proportion of value added by logistics processes is high. Mainly, the infrastructural situation in an industrial agglomeration is used to support the supply chain processes. Also the partners within a supply chain, who are located in such industrial agglomerations, are integrated in one of these main supply chain processes, but the linkage of these main supply chain processes barely take place. In an industrial agglomeration the concentration of logistical activities has priority.

For the process-driven reference model for sensitive logistics nodes the hierarchical structure of the SCOR-Model is used and adapted to the presentation of the problem of industrial agglomerations. Therefore, four levels are defined. Due to varying conditions in the individual industrial agglomerations, a configurable reference model is to be developed, with the aim of allowing for application-specific adaptations. This is achieved through a modular structure.

The definition of the four levels takes place according to the organisational objects. On the top level, a single industrial agglomeration is considered in its entirety and the processes concerning all business partners within are depicted. On the second level, the partners in an industrial agglomeration are clustered, based on the main business activities they do. On the next hierarchical level, the clusters are further divided into sub-clusters based on distinct characteristics in the cluster-specific business activities. There, the modeling of processes, which represent the important operations of the sub-clusters, is performed. On the fourth level, these processes are modeled and assigned to the business partners in the sub-cluster.

By interconnection of the processes in the cluster respectively in the sub-cluster, the relevant processes in sensitive logistics nodes are obtained, which can be taken as a basis for the decision-making, if a damaging event occurs. For this purpose, standard strategies for possible damage need to be developed as a base for necessary measures. They contain a predefined package of measures and support short-term decision making with the aim to initiate a quick resumption of the flow of goods after a disruption.

FREIGHT VILLAGES

There are many logistics nodes which can be seen as sensitive. Our approach is mainly based on freight villages. They are a special kind of an industrial agglomeration, connecting local and long-distance traffic. Freight villages can be characterized by high in- and outgoing transport volumes combined with turnover and warehouse activities and are distinguished by a high degree of integration of the external and internal processes. They are areas where different companies, as for instance forwarding agencies, logistics service providers, logistic intensive trading and industrial companies such as different transport carriers are united (Kessler et al. 2009). Both, multiple partners of a single supply chain as well as companies belonging to different supply chains can be located within the same freight village. Hence, they can be described as important and sensitive logistics nodes within a supply chain network.

In Germany, there is currently a network of 35 freight villages. For our approach, two of these freight villages were analysed. The logistics processes taking place in these selected freight villages are recorded and modeled to construct the empirical background. Also, the business partners internal of a freight village are clustered.

On the top level, the processes which concern cross-company activities are ascertained. The next level includes the processes within the individual clusters. For instance, the intermodal transport builds one module on the second level and can be divided into two sub-clusters on the third level, based on different transport carriers. On the first-line, the recorded processes are more specified.

CONCLUSIONS AND FURTHER RESEARCH

The process-driven reference model enables the depiction of the processes in different freight villages. In addition, it builds the base of further research: Besides the risk identification, standard strategies for possible damage need to be developed. To make the identified risks available to the support of decision-making, these will be depicted exemplarily. In this context the application of decision trees, decision matrices and decision networks will be proven systematically for structuring the identified risk sources and to derive decision paths. These are consulted for the derivation of standard strategies. The next step is to evaluate scenarios that support the decision-making process dynamically on the operational level, with the help of a multi-agent based simulation approach.

ACKNOWLEDGEMENT

PreparedNET is a cooperative research project, advanced by the German Federal Ministry of Education and Research (BMBF) in the course of the announcement „Securing supply chains‟ (“Sicherung von Warenketten”) in the context of the program „Research for Civil Security‟ (“Forschung für die zivile Sicherheit”) by the Federal Government. It is part of the „Federal Government hightech-strategy‟. The Institute of Shipping Economics and Logistics (Bremen) is in charge of the project leadership.

REFERENCES

Buscher U, Wels A, Winter D (2007) „Eine bibliographische Analyse zum Supply Chain Risikomanagement unter besonderer Berücksichtigung der Risikoquantifizierung‟, in Otto A & Obermaier R (Eds.) Logistikmanagement 2007: Analyse, Bewertung und Gestaltung logistischer Systeme, Wiesbaden: Gabler, p. 347-375.

Haasis H-D (2008) „Produktions- und Logistikmanagement: Planung und Gestaltung von Wertschöpfungsprozessen‟, Wiesbaden: Gabler, 2008.

Jüttner U, Peck, H, Christopher, M (2003) „Supply Chain Risk Management: Outlining an Agenda for Future Research‟, in International Journal of Logistics: Research and Applications, Vol. 6, No. 4, p. 197-210.

Kersten W, Hohrath P, Winter M (2008) „Risikomanagement in Wertschöpfungsnetzen – Status Quo und aktuelle Herausforderungen‟, in Wirtschaft und Management, Heft Mai/ 2008, p. 7-21.

Kessler S, Krause S, Nagel L (2009) „Nutzungsmöglichkeiten der Workbench zur Unterstützung des Planungsprozesses von Güterverkehrszentren‟, in Buchholz P & Clausen U (Eds.) Große Netze der Logistik: Die Ergebnisse des Sonderforschungs-bereichs 559, Berlin/ Heidelberg: Springer, p. 271-295.

Peck H (2005) „Drivers of supply chain vulnerability: an integrated framework‟, in International Journal of Physical Distribution & Logistics Management, Vol. 35, No. 4, p. 210-232.

Pfohl H-C, Köhler H, Thomas D (2010) „State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice‟, in Logistics Research, 2 (1), p. 33-44.

Poluha R G (2010) „Quintessenz des Supply Chain Managements‟, Berlin/ Heidelberg: Springer, 2010.

Ritchie B, Brindley, C (2009) „Effective Management of Supply Chains: Risks and Performance‟, in Wu T & Blackhurst J (Eds.) Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers, London: Springer, p. 9-28.

Romeike F, Finke R B (Eds) „Erfolgsfaktor Risiko-Management: Chance für Industrie und Handel. Methoden, Beispiele, Checklisten‟, Wiesbaden: Gabler, 2003.

Wagner S, Bode C (2007) „Empirische Untersuchung von SC-Risiken und SC-Risikomanagement in Deutschland‟, in Vahrenkamp R & Siepermann C (Eds.)

Risikomanagement in Supply Chains: Gefahren abwehren, Chancen nutzen, Erfolg generieren, Berlin: Erich Schmidt, p. 59-79.
Wagner S, Kemmerling R, Kersten W, Böger M (2010) „Supply Chain Risikomanagement: Besonderheiten und Herausforderungen für kleine und mittlere Unternehmen", in Engelhardt-Nowitzki C, Nowitzki O, Zsifkovits H (Eds.) Supply Chain Network Management: Gestaltungskonzepte und Stand der praktischen Anwendung, Wiesbaden: Gabler, p. 97-116.
Winkler H, Kaluza B (2007) „Überlegungen zu einem integrierten Supply Chain Performance- und Risikomanagement", in Vahrenkamp R & Siepermann C (Eds.) Risikomanagement in Supply Chains: Gefahren abwehren, Chancen nutzen, Erfolg generieren, Berlin: Erich Schmidt, p. 319-335.
Zsidisin G A, Ragatz G L and Melnyk S A (2005) „The Dark Side of Supply Chain Management", in Supply Chain Management Review, Vol. 9, No. 2, p. 46-52.

FUNCTIONAL MODELS FOR LOGISTIC PLATFORM BASED ON EXPERIMENTAL DATA

Domenico Gattuso, Gian Carla Cassone, Fabio Politi
Mediterranea University of Reggio Calabria (Italy)

Introduction

The logistic platforms, different for structure and functions, are fundamental elements of transport network and their functionality influences the efficiency of intermodal chain and the provisioning and distribution phases of supply chain.

The paper proposes functional and topological models for operational analysis of logistic platforms. These models are funded on experimental data, derived from direct surveys at freight interregional logistic platform Kuehne+Nagel of Cameri (Novara-Italy).

These models are directed towards the definition of optimization procedures for the management of logistic platform processes by using simulation approach.

The methodology can be put on others contexts (ports, freight villages, etc.). The proposed analysis and modellization are useful tools for efficiency and effectiveness evaluations, and they allow the control of logistic process, in relation to monitoring of functional parameters, such as costs and quality, in order to assure competitive effectiveness to the logistic supply chain.

Functional and topologic models to represent freight logistic platforms

Logistic platform functional representation aims to show the terminal functional components as well as their existing relations. It can meet various requirements, such as analyses and assessments of the node spatial, organizational and relational structure.

Sector literature includes several examples of functional representation for intermodal nodes (Ballis and Goulias, 2002; Cheung et al., 2002; Henesey, 2004; Li et al., 2004; Cartenì and de Luca, 2009) related to container ports, freight villages and cross docking terminals. The functional representation is carried out through the use of block diagrams which show the typical utilities of the terminal and the connections between the different areas composing the logistic platform.

In particular for a freight interregional logistic platform, the survey has pointed out that the physical, organizational and operational structure of the platform is related to the specialization for chain (food, various goods, etc.) and to the dimensions of handled load units (LU) (little items, pallets, bulky goods). In general, according to such logic, the structure of a freight logistic platform can be schematized in six operational macro-areas in sequence. These areas can be gathered in three pertinence zones: arrival zone, storage zone and consignment zone (Fig. 1).

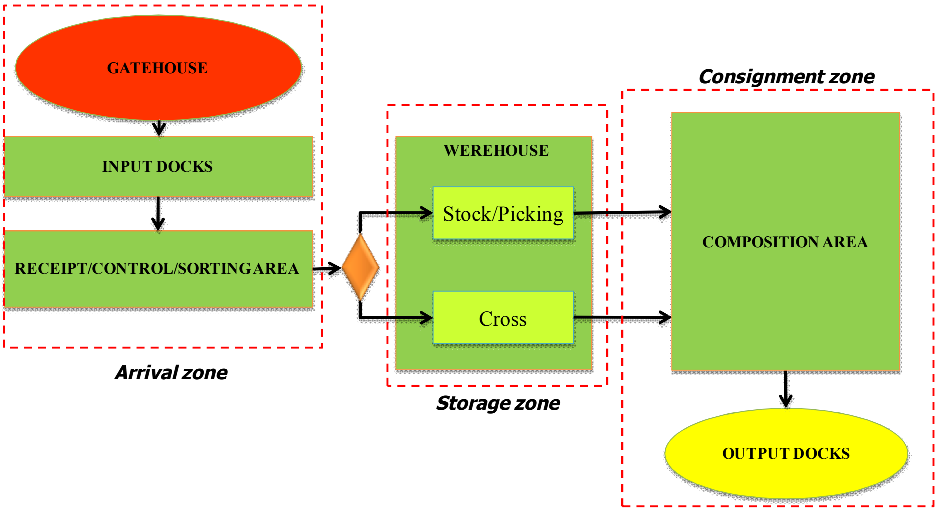


Figure 1 – Functional representation of freight logistic platforms

It is possible to use a representation more detailed for describing the functionalities of every zone in relationship to the activities that develop in it. For example figure 2 shows the sequence of activities that perform in arrival zone to manage inbound trucks.
Verified the congruence of the quantity and the type of goods transported by truck on the base of arrival orders, gatehouse assigns to the inbound vehicle a dock and a number of order. The dock is assigned in relation to the load typology in order to optimize the following operations of unloading and storage, while the number of order is assigned on the base of the arrival schedule. So the truck waits for service and when, in the assigned dock, a door is free, in respect of order number, it goes in the platform and the unloading operations start. The unloaded LUs are checked and if they are suitable, they come to warehouse, otherwise they are loaded on origin truck, that, at the end of this operation, leaves the dock.

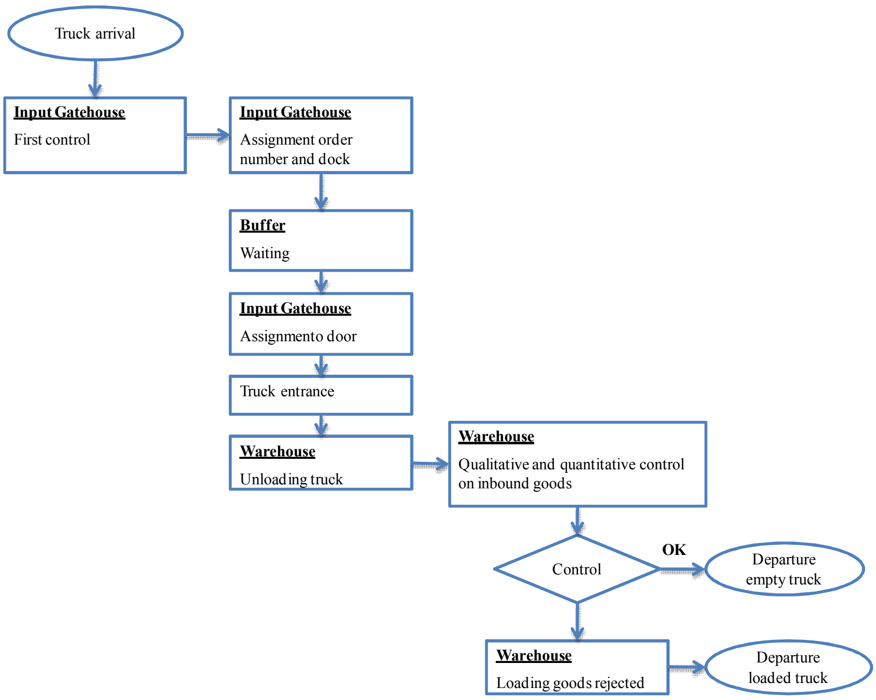


Figure 2 – Functional representation of arrival zone

The topological representation of operations is made through a graph which allows the schematization of activities. In sector literature there exist many examples of topological representation of intermodal terminals (Frankel, 1987; Gattuso and Musolino, 2002;

Russo, 2005; Russo and Cartisano,2005; Gattuso et al., 2008); many topological representations are referred to ports and freight villages. In general, graph nodes represent physical and/or temporal points where an elementary operation, which is part of the transport cycle of goods and of their possible manipulation/processing, starts or finishes; on the contrary, line segments represent goods handling and/or processing operations. For an interregional freight logistic platform it is possible to design several graphs in relation to management and handling procedures of LUs that can be homogeneous and/or inhomogeneous pallets. As an example, figure 3 shows the graph of logistic platform related to management/handling of inbound homogeneous pallets and outbound inhomogeneous pallets with "groupage" activities. In accordance with the proposed functional representation, the supply of logistic platform can be represented by means of a graph divided into three sub-graphs: arrival zone, storage zone and consignment zone. In the graph it is possible to distinguish between movement and stop links: the first ones are related to physical transfer activities of trucks and/or LUs, the second ones are related to stop times (e.g. waiting time for trucks). Table 1 shows links of the graph with the represented activity.

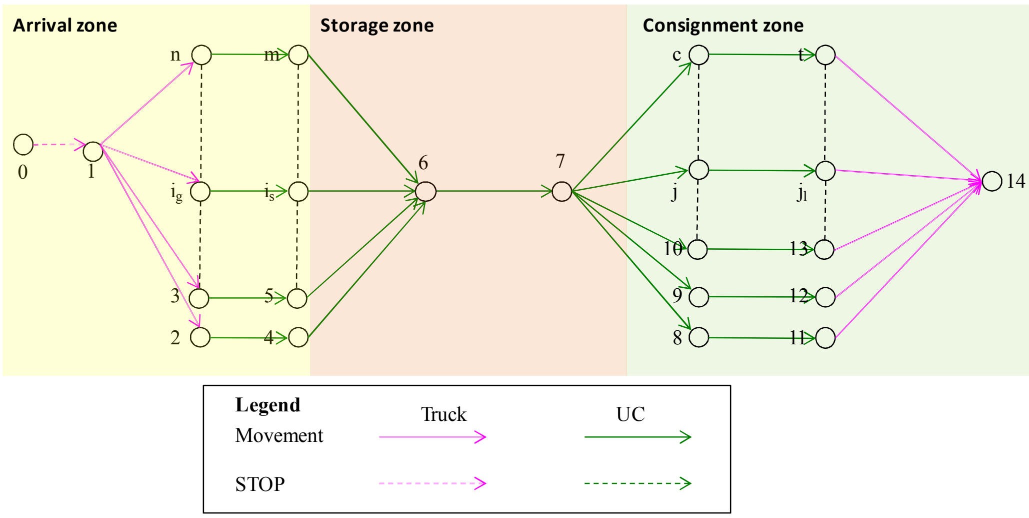


Figure 3 – Topologic representation of logistic platform

Table 1 – Graph links

Link	**Activities**
0-1	Truck Waiting
1-i_q	Truck entrance
i_q-i_s	Unload/Control
i_s-6	Transfer to warehouse
6-7	Storage and lifting/lowering activities
7-j	Load composition
j-j_l	Load
j_l-14	Exit

Statistical analysis

The topological representation of logistic platform is significant if each link of the graph is related to a quantitative value or a cost (monetary or temporal). A statistic analysis has been realized to obtain quantitative values for each link. The analysis has been carried out with reference to a large database derived from direct survey in the interregional logistic platform of Cameri. The analyzed sample is related to 3,500 inbound trucks, to 300 unload operations, to 3,500 load composition activities and 200 load operations. The statistical analysis of data has allowed the specification and calibration of probability density functions related to waiting time in buffer (T_w), services time (T_S), unload time (T_{unload}), composition time (T_C) and load time (T_{load}). The definition of probability density functions has been derived through the comparison between the real and theoretical frequencies, as well as by using appropriate statistical tests.

Waiting time for trucks
In the analyzed logistic platform, the trucks arrival is not managed in accordance to a FIFO (First In First Out) logic, but the entrance order depends from different factors what, for instance, the type of goods and, as a consequence, the assigned dock where makes the unloading operations; a truck comes in node if a door, in correspondence of dock assigned, is free. So the waiting time of a truck is linked both to schedule of arrival and docks working. This management policy derives from need to optimize the activities that follow the unloading (qualitative and quantitative control, sorting, storage); in fact every dock is in correspondence of a specific area of warehouse. For this reason, the analysis of data has been developed differentiating in docks (docks A, B, C, D, E). The waiting time variable has been analyzed by using two different continuous probability distributions: the exponential distribution and the Erlang distribution for different values of characteristic parameter k. For example figure 4 shows the trend of real cumulative frequencies and of those theoretical for the dock A.

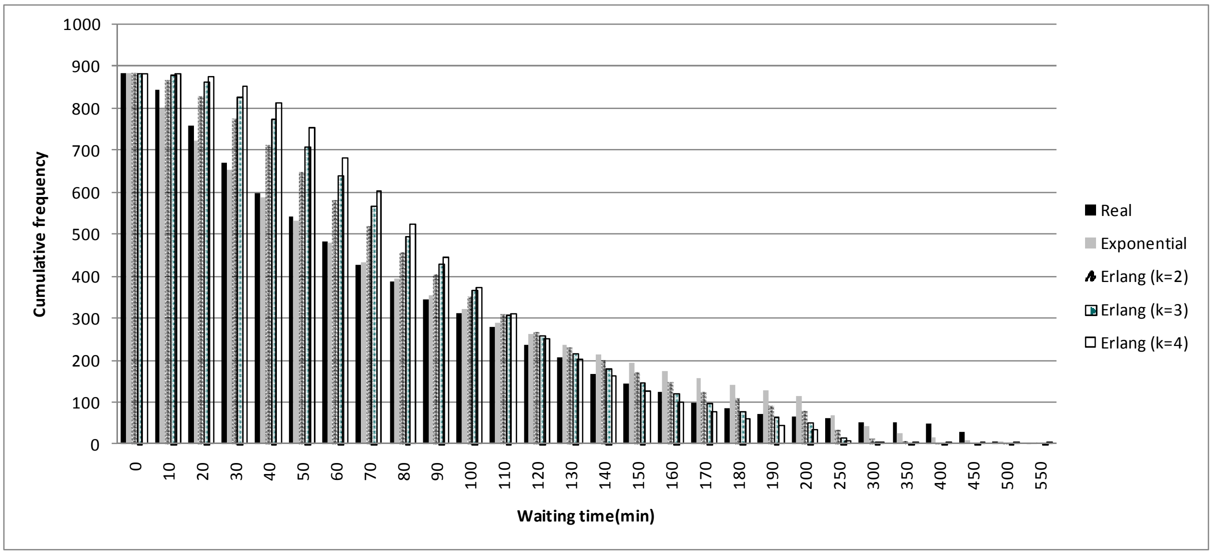


Figure 4 – Real and theoretical cumulative frequencies for waiting time variable

Table 2 shows mean, variance and standard deviation for T_w variable with reference to several operative docks. For an exponential variable the mean represents the scale parameter of distribution, while for a Erlang variable mean (μ) and variance (σ^2) are:

$$\mu = \frac{k}{Q} \qquad \sigma^2 = \frac{1}{k \cdot Q^2}$$

with *k* and *Q* characteristic parameter of distribution.

Table 2 – Mean, Variance and Standard deviation for T_w variable

	Dock A	**Dock B**	**Dock C**	**Dock D**	**Dock E**
Mean (min)	98,73	95,27	76,75	113,60	121,73
Variance (min^2)	10.997,96	12.310,42	6.742,94	10.997,96	18.362,97
Standard deviation (min)	104,87	110,95	82,12	129,82	135,51

The comparison between real and theoretical frequencies and the result of χ^2 test at the 5 percent significance level allow to affirm that the fit of the exponential distribution is acceptable for all dock.

Service time for trucks

The service time represents the time that needs:

- to position and to moor the truck in correspondence of dock and door assigned it;
- to complete the unloading operations;
- to realize the first control on inbound goods;
- to load on truck pallet rejected;
- to close semitrailer and to unrig the door.

The service time depends from the conditions of load of the inbound truck, but also from the operational conditions of the dock where the truck is served or from the modalities used for to unload goods (manual or with handling means), from the number of employees and means used to the dock to unload the truck and to carry out the controls, from the number of doors in the dock, etc. The study of service time variable has been realized with reference to Gauss and Gamma distribution distinguishing for operative dock. For example figure 5 shows the trend of real and theoretical frequencies for dock B. Table 3 shows mean, variance and standard deviation for service times for each operative docks. For a Gauss distribution mean and standard deviation are characteristic parameters of distribution, while for a Gamma distribution mean and standard deviation are:

$$\mu = \frac{a}{\lambda} \qquad \sigma^2 = \frac{a}{\lambda^2}$$

with *a* and λ characteristic parameters of distribution.

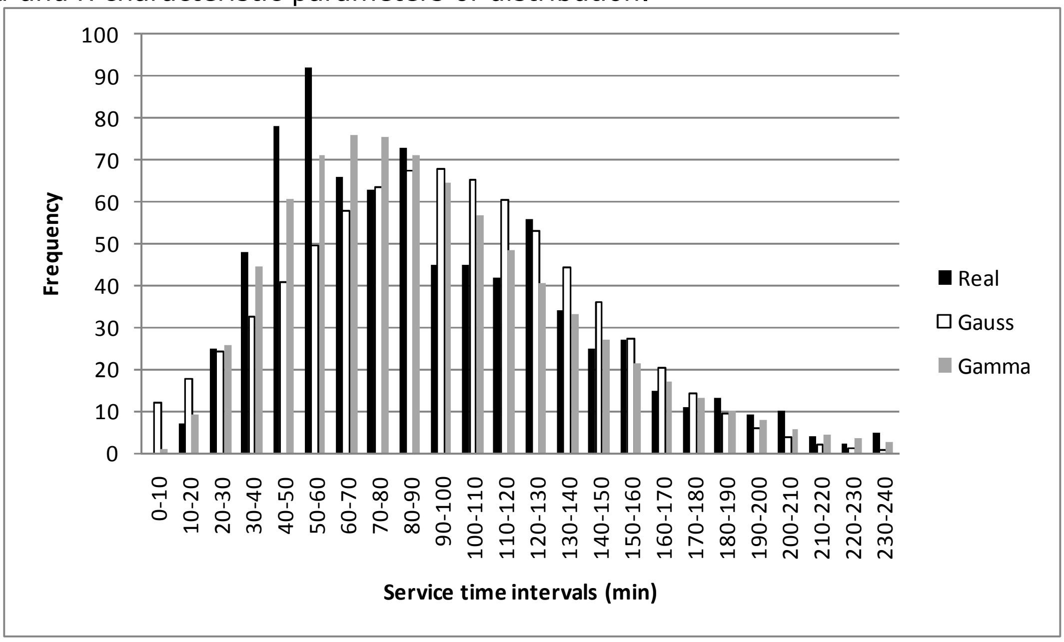


Figure 5 – Real and theoretical frequencies for service time variable

Table 3 – Mean, Variance and Standard deviation for T_S variable

	Dock A	**Dock B**	**Dock C**	**Dock D**	**Dock E**
Mean (min)	66,15	92,03	86,61	101,23	112,74
Variance (min^2)	1.364,12	2.175,52	2.803,16	2.476,63	3.221,42
Standard deviation (min)	36,93	46,64	52,94	49,77	56,76

The real frequency have a positive asymmetric distribution; for this reason Gamma distribution has been chosen to describe the real trend of service time variable. The comparison between real and theoretical frequencies and the result of χ^2 test at the 0,1 percent significance level have justified this choice.

Unload time

The time taken in unload of truck depends from the conditions of load of the truck, but also from the modalities used to unload goods. The analyzed data show that the average time to unload a truck is equal to 15 minutes (variance 63.25 min2 and standard deviation 7.95 min). The unload time variables has been analyzed with reference to Gauss, LogNormal and Gamma distributions. Figure 5 shows the trends of real and theoretical frequencies. The Gamma distribution is that which better it represents the trend of real frequency; in fact the result of χ^2 test at the 0,1 percent significance level shows that the fit of the gamma distribution is acceptable.

Storage time

The evaluation of storage time is not easy for an interregional logistic platform where groupage/degroupage activities are developed. In fact the homogeneous inbound LUs are moved to warehouse, here they are placed in higher parts of shelves. In case of need the LUs are let down, unpacked and placed in lower parts of shelves where they can be by workers easily. So the LU is broken up into packages that are moved from warehouse to consignment zone. These packages will constitute the mixed outbound LUs. The evaluation of average storage time for product type can be realized with reference to orders.

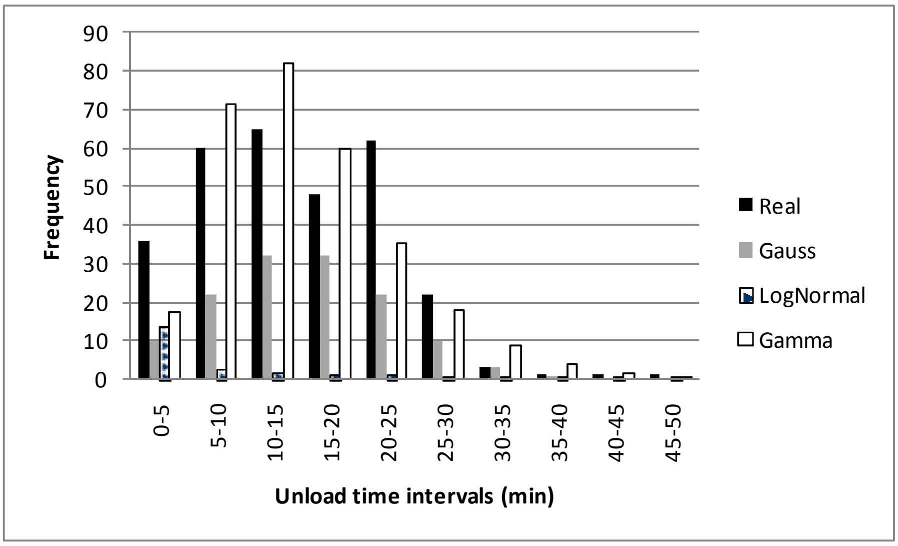


Figure 5 – Real and theoretical frequencies for unload time variable

Load composition time

Load composition time is gotten as sum of three different part:

- the tacking and positioning time in the consignment area of every element (piece or package) that will constitute the outbound LU;
- the time to realize the quantitative and qualitative controls;
- the time to constitution of outbound LU (packing pallet).

The average time to compose an outbound load is equal to 401 minutes (standard deviation 109 min). This statistic is not significant, in fact the composition time of outbound load is strictly related to the number of outbound LU that is necessary to prepare for the specific consignment. The figure 6 shows as T_C variable increases in a linear way to the growth of the number of LUs to compose (n_{LU}) according to the following relation:

$$T_C = 14{,}1 \cdot n_{LU} + 1{,}04 \quad [min]$$

with R^2 equal to 0,90.

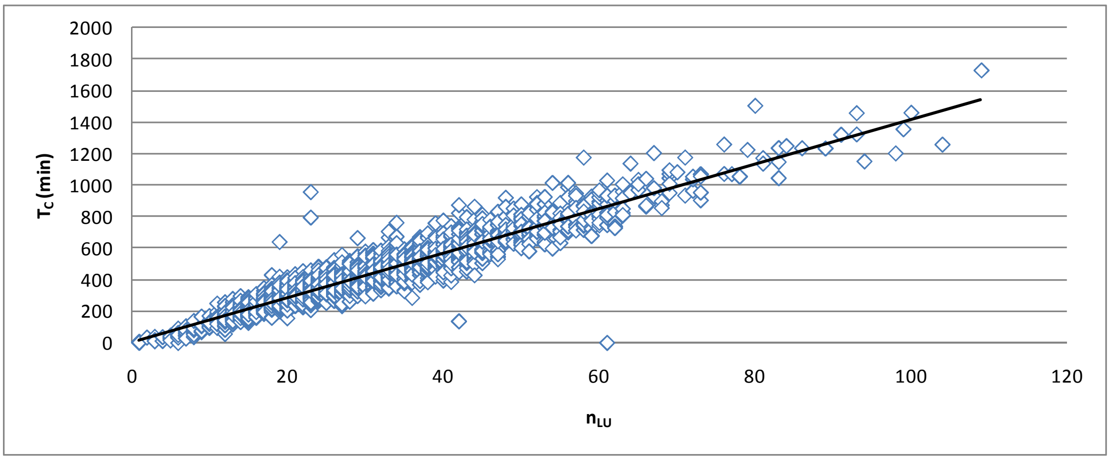


Figure 6 – Relation between T_C and n_{UC}

For this reason the study of load composition time has been realized with reference to class determined in relation to the number of composed LUs. These class are showed in table 4, where mean, variance and standard deviation of T_C variable are specified.
The analysis of load composition time variable has been realized with reference to the Normal distribution. For example Figure 7 shows the trend of real and theoretical frequencies for outbound loads made by 10-20 pallets.

Table 4 – Mean, Variance and Standard deviation for T_C variable

			n_{LU}			
	<10	**10-20**	**20-40**	**40-60**	**60-80**	**>80**
Mean (min)	67,41	243,00	407,35	673,86	951,25	1.289,33
Variance (min^2)	1.620,30	3.009,51	8.858,44	13.858,75	30.589,74	26.886,71
Standard deviation (min)	40,25	54,86	94,12	117,72	174,90	163,97
Observations N.	90	994	1965	461	63	17

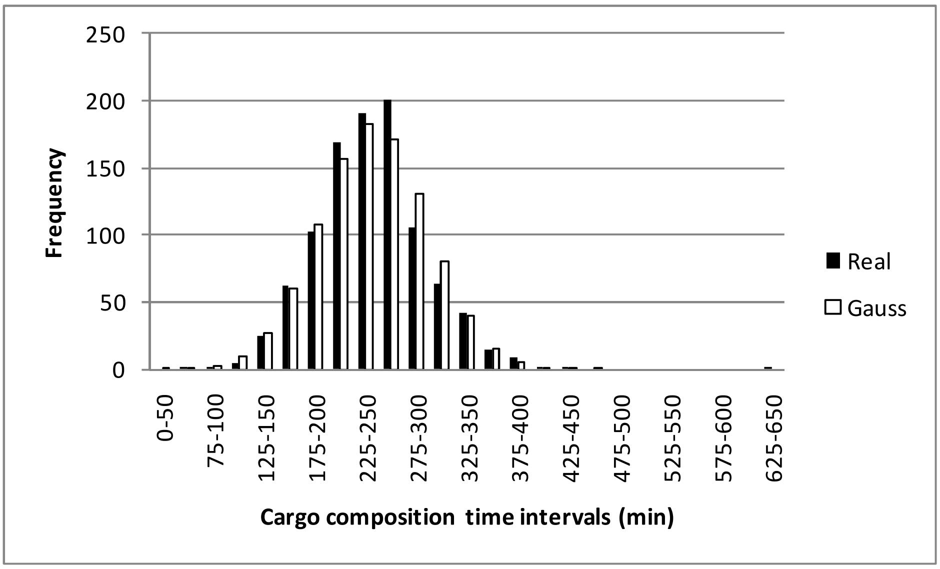


Figure 7 – Real and theoretical frequencies for load composition time variable

The Normal distribution has been thought acceptable in order to represent the load analyzed variable (for every class of pallets) on the base of the result of χ^2 the test at the 0,5 percent significance level.

Load time
The load time of outbound trucks depends from the number of loaded LUs and from the rapidity of the operations or from the number of employees and means used to load the truck. The average load time is equal to 29 minutes (variance 62.5 min^2, standard deviation 7.9 min). The analysis of load time variable was made with reference to Normal and Gamma distributions. The trends of real and theoretical frequencies are showed in figure 8.

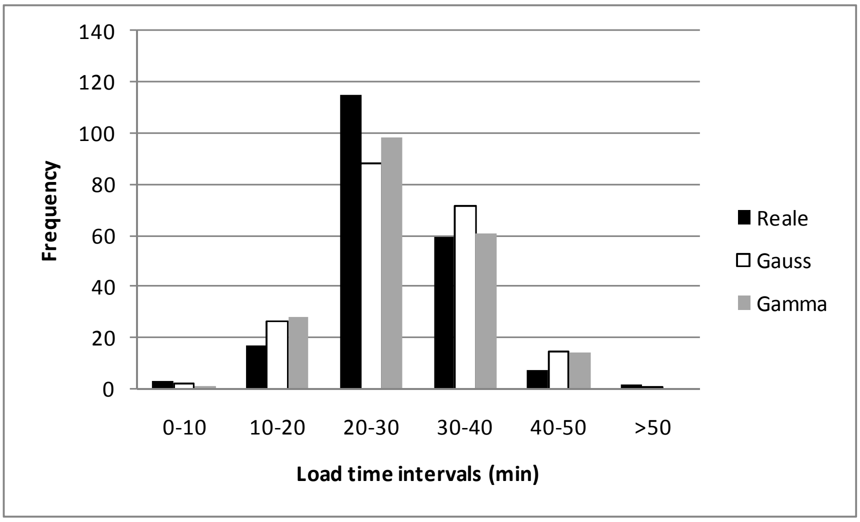


Figure 8 – Real and theoretical frequencies for load time variable

The comparison between real and theoretical frequencies and the result of χ^2 test at the 1 percent significance level allow to affirm that the fit of the gamma distribution is acceptable to represent the trend of load time.

Results on graphical scheme
The results of statistical analysis have allowed to realize a first topological representation (Figure 9) of considered freight interregional logistic platform.

A gatehouse (node 0) and five input docks (node A, B, C, D, and E) constitute the arrival zone of the platform. The docks are organized in doors for unload activities (4 for dock A, 9 for dock B, 3 for dock C, 9 for dock D and 9 for dock E). The several sectors of warehouse (nodes 69, 70, 71, 72 and 73) correspond to every dock. The warehouse sectors are subdivided into circuits in relation to product types (water and drink, pasta, detergent, etc.). In perfectly symmetrical way, five areas (nodes 74, 75, 76, 77 and 78) constitute the consignment zone; these areas are equipped with 42 doors for load activities. The links between the network nodes represent the developed activities to handle the inbound/outbound trucks (broken line) and the LU (unbroken line). In particular the waiting of trucks is represented by 0-A, 0-B, 0-C, 0-D e 0-E links; the unload activities by 1-35, 2-36, 3-37, 4-38, 5-39, 6-40, 7-41, 8-42, etc. links; the load composition operations are represented by 69-74, 69-75, 69-76, 69-77, 69-78, etc. links and the load activities by 74-79, 74-80, 74-81, 74-82, 74-83, 74-84, 74-85, 74-86, 74-87, etc. links. The thickness of links represents the time of the related activity.

Conclusions
The analysis of supply related to a freight logistic platform is a basic element both for functionality and efficiency analysis and to get ready optimization procedures of terminal processes and activities. Besides the definition of functional and topological model of supply is very important to specify simulation models and methods, that are useful as

tool of decision support along the cycle life of the system: from the planning phase to the dimensioning to the successive management ones. The paper proposes a methodological procedure to analyze the problems connected to functional organization of a logistic platform. The procedure is based on statistical analysis of experimental data that are come to direct survey. The proposed analysis has allowed both the specification and calibration of probability density functions related to the times of platform activities and the representation through graph of results. The results can be put on similar context (e.g. cross docking terminals).

REFERENCES

Ballis A., Goulias J. (2002). Comparative evaluation of existing and innovative rail-road freight transport terminals. Transportation Research part A (36), pp. 593-611

Carteni A., de Luca S. (2009). Simulation of a container terminal: estimation of equipment handling models and before and after analysis. Proceedings of XIII Meeting of the Euro Working Group on Transportation. 23-25 September 2009. Padua. ISBN 978-88-903541-4-4

Frankel E.G. (1987). Port Planning and Development, John Wiley and Soons, New York.

Gattuso D., Musolino G. (2002). Modelli di costo del trasporto marittimo in container e di interscambio modale. In Metodi e tecnologie dell'ingegneria dei trasporti. Seminario 2000. Cantarella G.E., Russo F. (a cura di). Ed. Franco Angeli Milano

Gattuso D., Cassone G.C., Polimeni A. (2008). Les coûts de transport dans la supply chain de l'automobile. 7èmes Rencontres Internationales de la Recherche en Logistique AVIGNON, 24 – 26 September 2008

Henesey L. E. (2004). Enhancing Container Terminal Performance: A Multi Agent Systems Approach. Department of Systems and Software Engineering School of Engineering Blekinge Institute of Technology Karlshamn, Sweden.

LiY., Lim A., Rodrigues B., (2004), "Crossdocking—JIT scheduling with time windows", *Journal of the Operational Research Society*, N. 55, pp. 1342–51.

Russo F. (2005). Sistemi di trasporto merci. Approcci quantitativi per il supporto alle decisioni di pianificazione strategica tattica ed operativa a scala nazionale. Ed Franco Angeli Milano

Russo F., Cartisano A. G., (2005). Modelli di rete per la simulazione di terminali marittimo Ro-Ro e Lo-Lo. In Metodi e tecnologie dell'ingegneria dei trasporti. Seminario 2002. Cantarella G. E. Russo F. (edited by). Ed. Franco Angeli Milano

CONSIDERATION OF DISTRIBUTION SYSTEMS THAT REPEATEDLY RE-USE STANDARDIZED CRATES

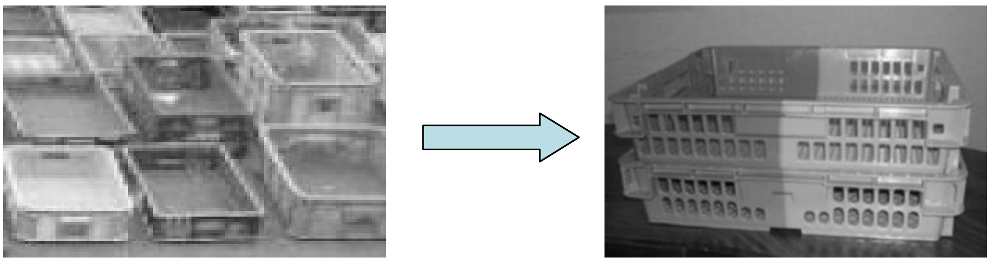
Etsuo Masuda, Yuji Yano
Faculty of Distribution and Logistics Systems, Ryutsu Keizai University, Japan

INTRODUCTION

Background

In the food processing and retailing industry, a variety of food products are transported between food manufacturers, distribution centers and retail stores using plastic shipping containers, which are referred to generically as "crates". These crates are often reused repeatedly by the same shippers. At present, there is very little standardization in the size and shape of the crates, or the type of plastic used. As Figure 1-a shows, there is a very diverse assortment of crate types[1]. Consequently, the used crates owned by each manufacturer must be sorted, stacked separately, and then collected by each manufacturer, in a process that consumes a great deal of time and space and generates high labor costs.

To address this problem, the Japan Supermarket Association and Japan Chain Stores Association set up a "Council of Standard Crate" in 2005[1], to establish standardized specifications for crates. In April 2007, this organization introduced the standardized crates[2] shown in Figure 1-b. Since then, the use of standardized crates and the introduction of handling systems based on the crates has been tested and discussed very frequently.



a: Non-standardizes crates b:Standardized crates

Figure 1: Plastic food crates

Objective

In this paper, we will perform a basic study of the methods for introducing a standardized crate handling system. In particular, we will focus on two different types of cleaning systems where the crates are washed before re-use, quantifying the processing capacity of each type (number of crates cleaned per hour), the number of crates in the system, and the processing parameters and comparing them with demand for crates, via a simulation study. Based on the results of this simulation, we will consider which system is most effective.

Related research

There are many other items used in the transportation industry which are reused over and over, just like food crates – the most well known examples include shipping containers, pallets, and foldable container cartons. The systems employed for reusing them could be similar to a system for reusing food crates. There have been previous studies involving systems for reusing these items; for example, a study of a tracking system to identify the location of pallets using a wireless (PHS) handset[3]; a global pallet rental system connected by EPCglobal network, for sharing pallets between Japan and Korea[4]; a management system for containers using RFID tags[5]; and a study of

[1] There are some 500 varieties of crates used to ship daily food items and refrigerated groceries.

cost effectiveness and CO_2 emissions impact when developing hybrid returnable containers[6].

However, there have not been any previous studies of systems for handling and reusing food crates, particularly ones which address the location and use of facilities for cleaning the crates. For hygienic reasons, food crates need to be cleaned thoroughly before they can be reused. Therefore it is very important, when considering efficiency, to determine the distribution of crates throughout the system, the processing capacity of cleaning facilities, and their relationship to demand for clean crates.

Subjects to study in this paper

This paper focuses on the crate cleaning facilities, and evaluates two different basic systems for cleaning and handling crates. Our research considers two primary parameters – the capacity of the cleaning facilities (crates/hour) and the number of clean crates available within the system. We also have considered the characteristics of similar systems.

OPERATION OF A DISTRIBUTION SYSTEM

Overview of the system

Figure 2 illustrates one example of a distribution system for reusing standardized food crates. Crates are collected and stored at the plants of food products manufacturers and other groups that ship food in crates. Facilities for collecting and storing the (already sorted) crates are also established at each distribution center. Separate crates are then filled with products at the distribution center and dispatched to stores. In this example, crate washing facilities are established either at distribution centers or the manufacturer's plant. Crates are collected at the distribution centers and returned to the manufacturer who originally shipped them (dotted lines). Similarly, the crates are collected at each store that receives deliveries, and then returned to the distribution center (dotted lines).

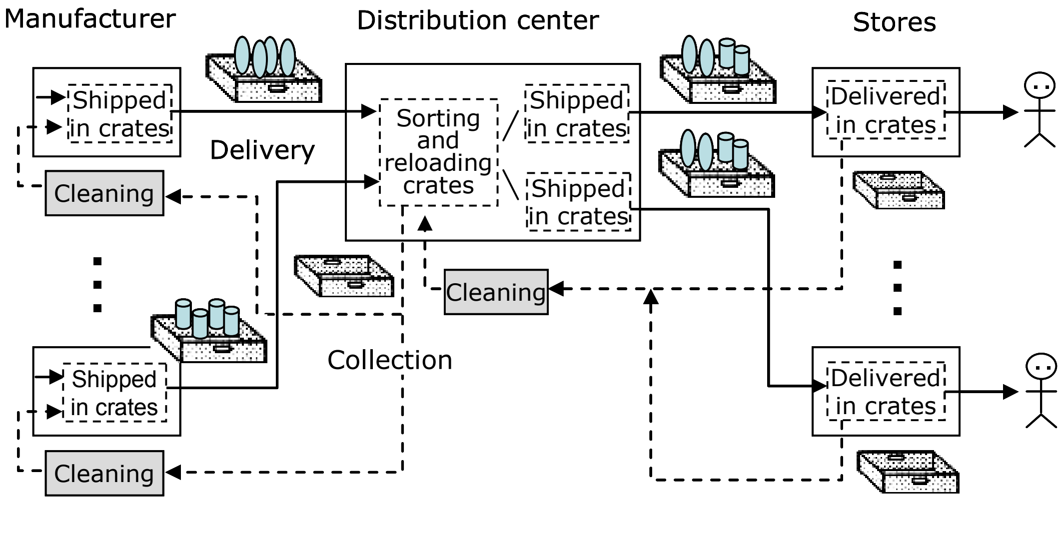
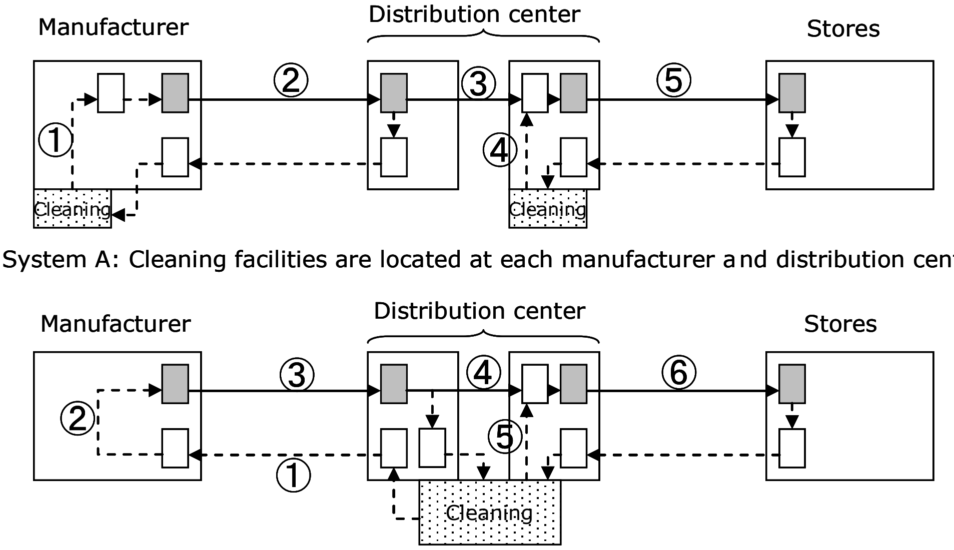


Figure 2: Example of a distribution system using standardized food crates

Operation of the system focusing on the location of cleaning facilities

In our basic proposal for implementing the system, one of the main points to consider is where to locate the facilities for washing crates. We considered two possibilities: one in which cleaning facilities are located at each manufacturer and distribution center (system A) and one in which distribution centers are organized into groups, and centralized cleaning facilities are established to serve several distribution centers (system B). These two methods are illustrated in Figure 3[2]. The circled numbers indicate the order of steps in the flow of materials (crates) through the system. The shaded and unshaded boxes indicate crates full of products (shaded) and empty crates (unshaded).



System B: Centralized cleaning facilities

Figure 3: Proposal for implementation of the system, focusing on the location of cleaning facilities

Crates containing products are delivered to multiple destinations (stores), where they are collected. A delivery vehicle then travels a route to multiple stores and collects the empty crates. The routes travelled by the delivery vehicles and the route travelled by the collection vehicle are separate, to allow adjustment to the most efficient route and schedule. The collected crates are then transported to a cleaning facility, cleaned and stored. The characteristics of the proposed system are as follows:

(1) In system A, the number of cleaning facilities (individual pieces of cleaning equipment) is large, and therefore both initial construction costs and maintenance costs will be higher. By contrast, in system B, several companies share the use of each cleaning facility, as well as sharing the crates themselves, so any changes in the location or methods of managing the cleaning facilities must be done cooperatively with the other companies that use the facilities (= less flexibility), and if a customer has any complaint about one of the crates, it is more difficult to determine and assign responsibility.

(2) In system A, the location of crates at a given time will be distributed over a larger number of locations, so the chance of any one location encountering problems with the supply of/demand for crates will tend to be higher than is the case for system B.

(3) The average transport distance for crates between manufacturers and distribution centers will be about the same[3], while the transport distance between customers and cleaning/distribution centers will be identical for both systems.

SIMULATION OF DISTRIBUTION SYSTEM

[2] In addition to the two systems we examined in this study, it would also be possible to have a system in which only the manufacturers operate cleaning facilities. However, in this type of system the process of returning and processing crates would become more complicated, and it would be more difficult for manufacturers to share the use of crates. For that reason, we did not consider this system in our study. Another possibility would be for a separate company to supply crates to the manufacturers on a rental basis, and the rental company would be responsible for collecting and cleaning the crates after use. We will discuss that possibility in the final section of this paper.

[3] In system A, vehicles that delivered goods could collect used crates on their return trip and take them to the cleaning facility. In system B, vehicles that delivered goods to the center would collect used crates from the cleaning facility on their return trip.

Below, we evaluate the parameters for each of the two systems, considering the processing capacity of the cleaning facilities and the number and distribution of crates, relative to the demand characteristics of each system.

System structure and parameters (see Figure 4)

1) We assume that there are two manufacturers using the system, and that each supplies a different type of food product, using the same standardized food crates. We assume that products from both manufacturers are delivered to 20 stores.

2) The parameters considered in this study are the processing capacity of each cleaning facility (number of crates cleaned per hour) and the number and distribution of crates within the system.

3) We assume that the distance from manufacturer to distribution/cleaning centers is equivalent to a one hour's drive in each direction.

4) We assume that the manufacturers process and dispatch products within one hour of receiving an order from a customer, and that the processing of each delivery at the distribution center also takes one hour. If there are no clean crates available at the time the shipment is due to be dispatched, this will be treated as equivalent to an "out-of-stock" situation.

5) To make the deliveries to the 20 stores, we assume that four delivery vehicles each cover a route encompassing five stores, and that it takes 3 hours for each vehicle to cover its assigned route. We also assume that distribution centers require 30 minutes (prior to the vehicle's scheduled departure time) to prepare the consignments. To collect empty crates, we again assume that four delivery vehicles each cover a route encompassing five stores, and that it takes 4 hours to complete the collection route[4]. Finally, we assume that the trucks start an empty crate collection run from the distribution center two hours after the delivery trucks depart.

6) The cleaning process is assumed to begin immediately upon delivery of the used crates to the cleaning center.

Demand for crates within the system (see Figure 4)

1) In our simulation, we assume that each store makes orders to the distribution center at six-hour intervals. The distribution center collects the order from all stores and makes bulk orders to each manufacturer, every six hours. Each order is rounded for the sake of simplicity, and expressed in "number of crates".

2) We also assume that each individual order from a store, on average, amounts to 50 crates of merchandise (we assume that orders from manufacturer A and those from manufacturer B are always equal). We assume that there is a normal distribution in the data, and the standard deviation is 10 crates[5].

Evaluation of system characteristics

[4] Using the above assumptions, we estimate that the total amount of time to complete one full cycle – from the start of consignment preparation to the final delivery of empty crates, is 6 hours, based on the following calculation (0.5hr + 3 hr + 4 hr – 1.5hr). The 1.5 hour deduction is our estimate of the average time-savings created by cases where the delivery of an order coincides with the collection of empty crates.

[5] Based on these assumptions, if the average order size from each store (for both manufacturers' products) is 50 crates, then the total order volume for each manufacturer would average 500 crates every six hours (50 crates x 20 stores / 2 manufacturers).

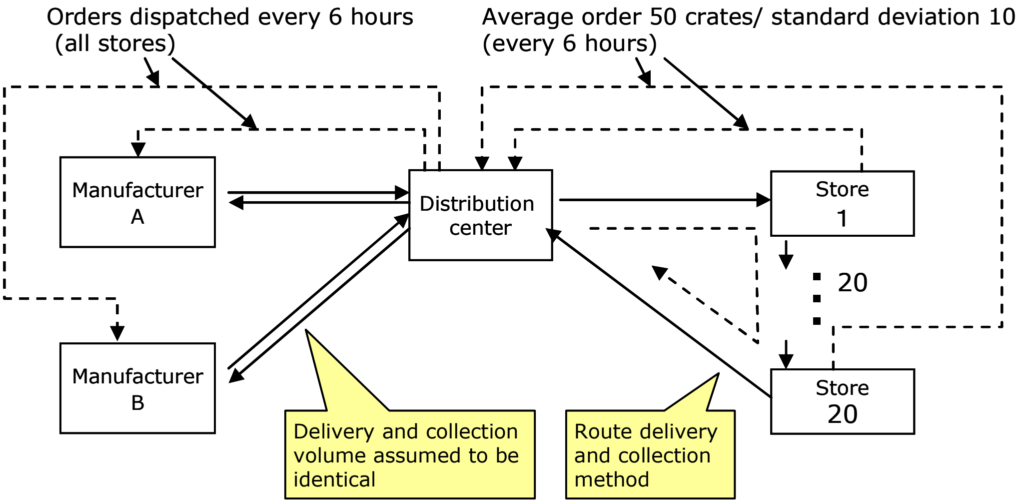
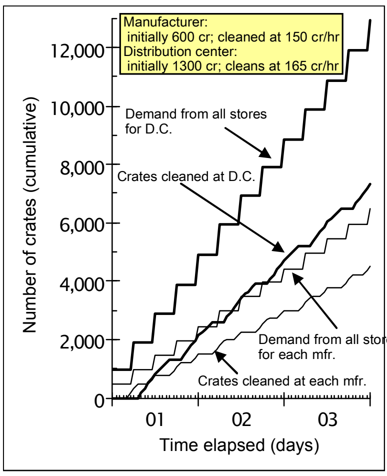
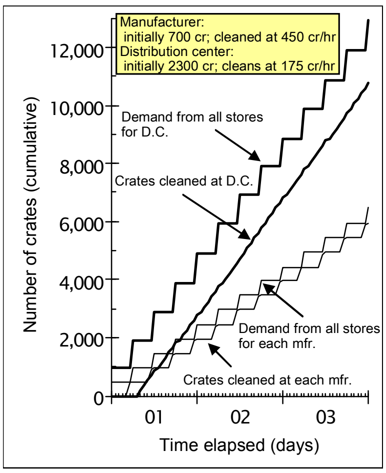


Figure 4: Overview of our model for the simulation

Figure 5 shows our evaluation model for system A, using two case examples. In the first, the number and distribution of cases is as follows: 600 at each manufacturer (1200 total) and 1200 at the distribution center. The processing capacity of the cleaning facilities is 100 crates/hour at each manufacturer and 200 crates/hour at the distribution center. In the second case example, the total number of crates is set at 2200 and the cleaning facilities at each manufacturer are assumed to have a processing capacity of 500 crates/hour. The diagrams show total demand for crates and total number of crates washed (both cumulative) on the time axis. In case 1 total demand from the stores and the number of crates cleaned both diverged from the figures for shipments from the manufacturer and shipments from the distribution center. As time progressed, the disparity increased, suggesting that cleaning capacity and shipment capacity are inadequate to meet the demand from stores. As Figure 6 shows, this eventually led to "stock-out" situations. By contrast, in case 2, there is no significant variance in the volume of crates cleaned and total store demand, suggesting that this system can provide a stable supply of products to the stores. There were no instances in which orders were met with a "stock-out" situation due to the absence of clean crates.



(i)



(ii)

Figure 5: Trends in number of crates for distribution system A

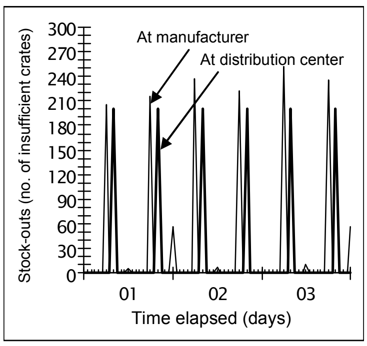
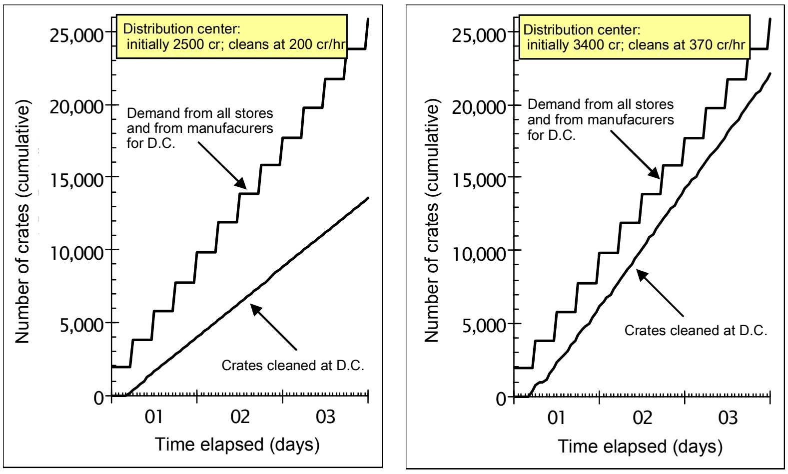


Figure 6: Identification of instances of "stock-outs" (for case shown in Fig 5-i)

Figure 7 shows our evaluation model for system B, using two case examples. In case 1, we assume that the total number of crates in the system is 2400, and that the processing capacity of the cleaning facility at the distribution center is 200 crates/hour.

Using this case example, the supply of crates again proves to be insufficient, and as Figure 8 shows, there are incidents of "stock-outs" due to an absence of clean crates. In case 2 we assume that the total number of crates in the system is 3400, and that the processing capacity of the crate cleaning facility is 360 crates/hour. In this case, there is no divergence in crate supply and store demand, suggesting that the system can provide a stable supply of products to the stores. In this case there were no "stock-out" incidents.



(i) (ii)

Figure 7: Trends in number of crates for distribution system A, over time

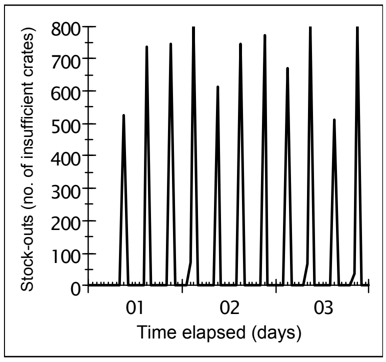


Figure 8: Identification of instances of "stock-outs" (for case shown in Fig 7-i)

These simulations illustrate the necessity of selecting an appropriate number of crates and an appropriate cleaning capacity, to fully meet demand from the stores

Stock-out situations relative to supply of crates and cleaning capacity

Looking at the parameters of total crate supply and cleaning capacity, for both system A and system B, we evaluated the two systems in terms of their ability to supply crates and avoid stock-outs. Out simulation was conducted over a theoretical period of 90 days (x24 = 2160 hours).

Table 1 and 2 show the results of our simulation of distribution system A. Table 1 shows the cumulative total number of insufficient crates in the simulation – that is to say, a summation of all times over the course of the simulation that one manufacturer was unable to make a delivery to the distribution center due to a lack of clean crates. Table 2 provides the same data, in the case of deliveries between the distribution center and individual stores. It should be noted that Table 2 is evaluating the conditions between the distribution center and stores, and therefore it assumes that there are no instances where the center fails to get the product from the manufacturer, due to a lack of crates. For that reason we only evaluated conditions in which the number of crates was over 800 and cleaning capacity was over 350/hour (the conditions necessary to ensure that there are no stock-outs between manufacturer and distribution center). Table 3 shows the results of the same simulation, for distribution system B. All three of these figures reflect the number of stock-outs over the course of the entire simulation (ie: 90 days).

Using these tables, we can determine the system conditions necessary in order to prevent any stock-outs due to a lack of clean crates. Using the data from Table 1, under system A the parameters of the system [number of crates available + cleaning capacity (crates/hour)] for each manufacturer must be greater than or equal to 1150 (for example, 800 crates and a processing capacity of 350 crates/hour). Using the data from Table 2, at the distribution center level the parameters must be at least 2475 (for example, 2300 crates and a cleaning capacity of 175 crates/hour). Using the data from

		Cleaning capacity				
		300	350	400	450	500
Number of crates*	500	36107	27207	18307	9683	3402
	600	18300	9683	2969	249	3
	700	2969	249	3	0	0
	800	3	0	0	0	0

*Numbers are the total for each individual manufacturer

Table 1: **System A** – number of stock-outs based on crate volume and cleaning capacity at the manufacturer level

		Cleaning capacity				
		160	165	170	175	180
Number of crates*	2000	15069	7195	5949	5917	5917
	2100	14944	4964	904	518	498
	2200	14844	4379	205	6	6
	2300	14744	4222	57	0	0

*Numbers are the total of all crates at the distribution center, used for delivery to all stores

Table 2: **System A** – number of stock-outs based on crate volume and cleaning capacity at the distribution center

		Cleaning capacity				
		330	340	350	360	370
Number of crates*	3100	13222	6844	4375	3060	2809
	3200	10830	2805	1123	604	391
	3300	9746	1169	314	106	47
	3400	9095	569	31	0	0

*Numbers are the total of all crates in the system – those used for delivery from manufacturer to distribution center, plus those used for delivery from the distribution center to all stores

Table 3: **System B** – number of stock-outs based on crate volume and cleaning capacity at the distribution center

Table 3, the overall parameters for system B must be at least 3760 (for example, 3400 crates and a cleaning capacity of 360 crates/hour).

There are numerous possible combinations of total crate availability and cleaning capacity that will allow the system to avoid stock-out situations. The question that now must be addressed is what combination of parameters to select, to establish an optimal system. The best way to determine this would be to obtain data on the total life-cycle cost of cleaning equipment and plastic crates (including operating costs). It is also necessary to decide whether to employ system A or system B. To make this decision, one must consider not only cost, but also the ease of allocating crates, and the responsibility for operating the cleaning equipment.

CONSIDERATION OF SIMILAR DISTRIBUTION SYSTEMS

We will now consider two potential variations on the "System B" example used in our simulation.

Centralized cleaning system operated by crate rental company

In this case, we assume that a separate vendor takes care of all crate cleaning activities. In this system there would be two stages in the product flow (for crates). The first stage would be as follows: Crate rental company → Manufacturer → Distribution center → Crate rental company (for cleaning). The second stage would be: Crate rental company →

Distribution center → Store → Distribution center → Crate rental company (for cleaning). If the rental company were located at a significant distance from the distribution center, it would be necessary to consider the increased time component in transporting crates between the center and the crate rental company, and therefore more crates would be needed. If the rental company were located near the distribution center, however, the flow would be pretty close to that examined in our simulation of System B.

Cleaning systems operated at two separate distribution centers
In a situation where there are two distribution centers performing the same functions (product receiving, consignment sorting, shipment and delivery, crate cleaning), not only would the burden of cleaning work for each center be halved, but it might also be possible to reduce the total number of crates and the cleaning capacity.

Alternatively, it might be possible for the two centers to specialize, with one handling the receiving-consignment-shipment activities and the other doing the crate collection and cleaning. This would create a situation similar to the one described above, with a separate crate rental company.

CONCLUSIONS

In this study, we examined the characteristics of distribution systems for the continuous re-use of plastic food crates – System A, in which separate cleaning facilities are maintained at both the manufacturers and at the distribution center, and System B, in which cleaning is centralized at the distribution center. We also considered the characteristics of some similar systems.

The parameters of our simulation were the number of crates available within the system, and the processing capacity (crates per hour) of the cleaning facilities. In our simulation, both of these were examined relative to the total demand for crates, and the result data were tabulations of how many times the supply of crates failed to meet demand for crates (=a "stock-out" situation). This data was then examined to determine what combinations of the parameters – number of crates and cleaning capacity – would ensure that there were never any stock-outs. If our data is then correlated with the cost of crates and the cost of building and operating the cleaning facilities, it will be possible to determine the optimal parameters for such a distribution system. We also examined some possible variations on our "System B", which could be used to implement such a system.

In addition to System A and System B, there may be some other models which could be considered when selecting a distribution system that would clarify responsibility for maintaining and operating the cleaning facilities. It is likely that issues of responsibility and reliability will also need to be considered, along with cost efficiency, when selecting a system.

REFERENCES

[1]Japan Supermarkets Association(2005) "Counsil of Standard Crate", News Release, http://www.jsa-net.gr.jp/pdf/051003_butsuryu.pdf.

[2]Japan Supermarkets Association(2007) "Standard crates", News Release, http://www.jsa-net.gr.jp/pdf/20070425_butsuryu.pdf.

[3]Yasuhiro Kawahara et al.(2005) "Pallet Location Finding System for Physical Distribution Using PHS Terminal", Micromechatronics, 49(192).

[4]Sumio Yamazaki(2007) "Pallet rental system as global logistics infrastructure", Kaiun, No.955.

[5]Koichi Nagai(2008) "Road map for pallet network system with RFID", Communications of JIMA, 18(4).

[6]Toshinori Takahama(2009) "Development of hybrid returnable container and its and cost comparison with disposable container", JPI journal, 47(2).

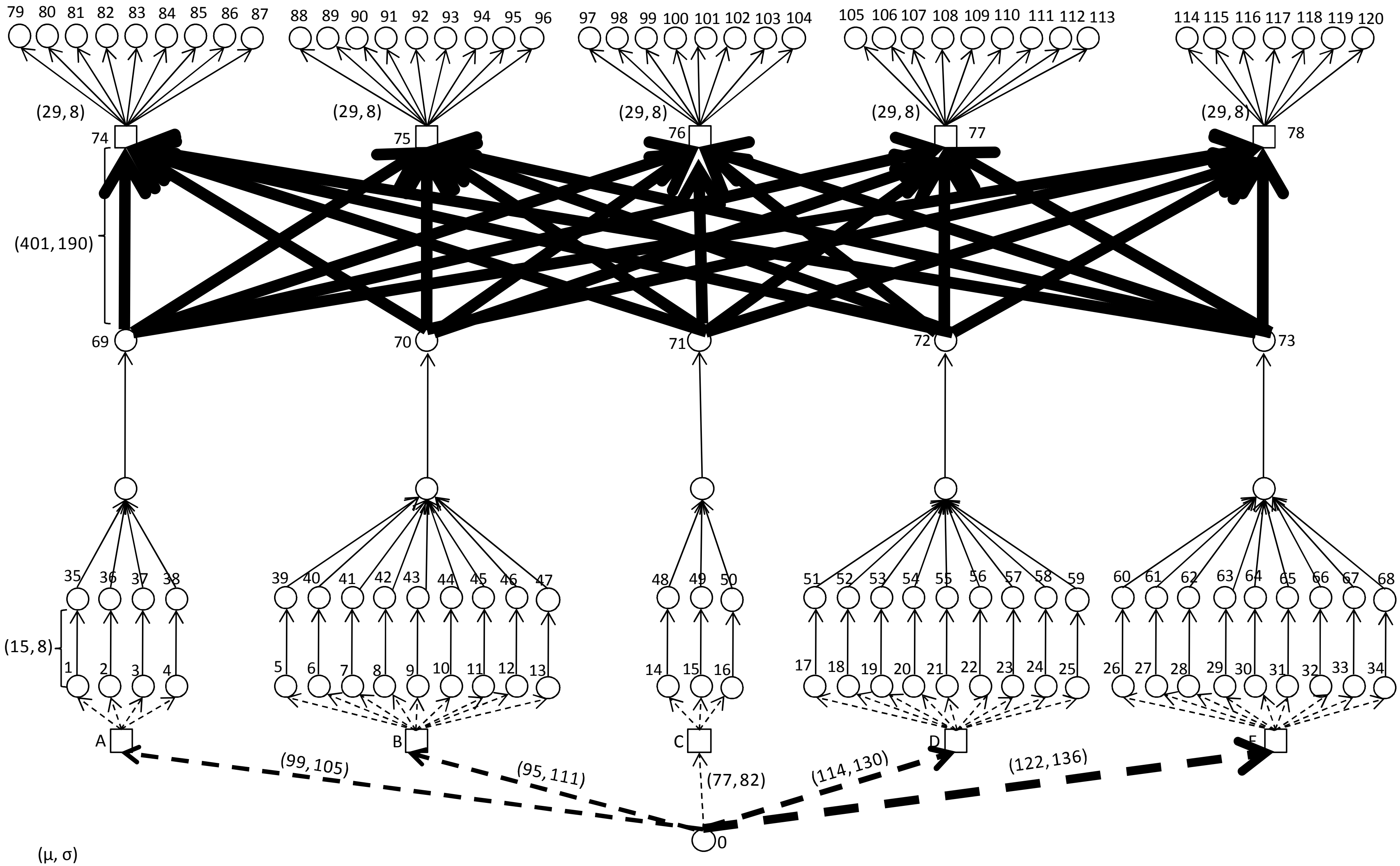


Figure 9 – Graph of interregional logistic platform of Cameri

ANALYSIS OF DIRECTED INFLUENCES BETWEEN U.S. AIR CARGO HUBS FROM TIME SERIES APPROACHES

Chien-wen Shen
Department of Business Administration, National Central University
No. 300, Jhongda Rd., Jhongli City, Taoyuan County 32001, Taiwan

Ching-chih Chou
Institute of Management, National Kaohsiung First University of Science and Technology
No. 2, Jhuoyue Rd., Nanzih, Kaohsiung City 811, Taiwan

ABSTRACT
To understand the regional relationships of U.S. air cargo hubs, this study analyzed their directed influences from the perspective of time series methodology. Cargo hubs studied in this paper include Memphis International Airport (MEM), Ted Stevens Anchorage International Airport (ANC), Louisville International Airport (SDF), Miami International Airport (MIA), Los Angeles International Airport (LAX), John F. Kenney International Airport (JFK), and O'Hare International Airport (ORD) because they are located in the U.S. and listed among the top twenty world's business airports by cargo traffic. From the results of Granger causality, there exist bi-directional influences between MEM and MIA. Besides, ORD and JFK Granger-cause the cargo throughputs of MEM. Our findings also indicate that there exist unidirectional influences from ORD and LAX to MIA while LAX can be predicted from MEM besides MIA. In addition, the throughputs of JFK, LAX, MEM, and MIA Granger-cause the throughput of SDF. Furthermore, the throughput of ANC can be estimated by the observations from MIA, MEM, SDF, and LAX.

INTRODUCTION
Since the U.S. began pursuing Open Skies agreements in 1979, liberalization of aviation services has reshaped the competitive landscape of civil transport. Although this policy change results in revenue growth, development of related tourism industries, balance of international trade, and improvements of economic efficiency, it also increases the competition of international aviation markets as a result of no restrictions on international route flights, number of designated airlines, and types of aircraft (Button and Taylor, 2000). To understand the changing market of air transport, the regional competition among airports has been an important research issue. For instance, Humphreys and Francis (2002) investigated airport-airline relationships in U.K. region and concluded that airport catchment size is a significant determinant of its lead position and attractiveness to the airlines. While one airport gains the dominant market, the neighbouring airports may offer lower rates to seize the spare portion of market opportunities. Study of Zhang (2003) used air cargo trade amount and volume as a simply description data statistics to analyze why Hong Kong becomes a significant air cargo hub in international market. Zhang further summarized the competitive factors of Hong Kong and its regional competitors from the angles of geographical location, costs, delivery times, infrastructure, customs, inter-modal transportation, and international aviation policy. Matsumoto (2004) proposed a gravity model that consists of GDP, population and distance introducing city-dummy variables to examine the international urban systems from the viewpoint of international air traffic flows.

To extend the understanding of regional competition among airports, this study applied the econometric approach of Granger causality analysis to investigate the directed influences between U.S. air cargo hubs from the perspective of cargo throughput observations. The Granger causality was proposed by Granger (1969) for the relationship analysis between time series data. Suppose that airport X and airport Y are paired to evaluate their Granger causality relationships. If airport X Granger causes airport Y, it implies that the cargo throughputs of airport Y can be better predicted by the past throughput observations of airport X. Because the approach of Granger causality analysis has several modelling advantages, it has been applied in the field of transportation research. For example, Lahiri and Yao (2006) used Granger causality to examine the predictability of proposed economic indicators for the transportation sector. Batchelor, Alizadeh, and Visvikis (2007) employed Granger causality to measure the significance of lagged spot and forward rates in the international seaborne freight market. They also evaluated other time series models such as ARIMA, VAR, VECM, and S-VECM. Meanwhile, the work of Ozbay, Ozmen-Ertekin, and Berechman (2007) applied Granger causality to test whether the gross county product (GCP) Granger-causes highway capital. Chang and Chang (2008) also applied the Granger causality tests to examine the causal relationship between air cargo expansion and economic growth in Taiwan. Hence, past studies indicate that Granger causality analysis is a suitable approach to investigate the relationships between transportation activities.

The investigation target of this study includes Memphis International Airport (MEM), Ted Stevens Anchorage International Airport (ANC), Louisville International Airport (SDF), Miami International Airport (MIA), Los Angeles International Airport (LAX), John F. Kenney International Airport (JFK), and O'Hare International Airport (ORD). These hubs were chosen for Granger causality analysis because they are located in the U.S. and listed among the top twenty world's business airports by cargo traffic in 2010. Table 1 summarizes their cargo landed weights from the database of Federal Aviation Administration. Statistics data indicates that the landed weight of these 7 airports accounted for 42.69% of the U.S. total in 2007. Due to their important roles in the regional market of cargo transport, this paper tried to investigate their directed relationships from the approach of Granger causality. Our findings can help policy makers to evaluate the potential impacts of one air cargo hub on another hub. This information is also critical to develop regional strategy for the growth of air freight transportation. In addition, prediction models can be constructed from these results to obtain statistically significant information and avoid the occurrence of spurious regressions. In the following discussion, a briefly overview of our investigated air cargo hubs is described in Section 2. Section 3 presents the time series methodology used in this study and Section 4 discusses our Granger causality findings. Finally, Section 5 provides our conclusions for the U.S. air transport market.

Table 1: The landed weight of major U.S. airports in 2007

Airport code	Airport name	City	Landed weight (tones)	% of overall in US
ANC	Ted Stevens Anchorage International Airport	Anchorage	10,562,163	13.79
MEM	Memphis International Airport	Memphis	9,771,908	12.76
SDF	Louisville International Airport	Louisville	5,215,613	6.81
MIA	Miami International Airport	Miami	3,715,107	4.48
LAX	Los Angeles International Airport	Los Angeles	3,430,618	4.48
JFK	John F. Kennedy International Airport	New York	2,556,999	3.34
ORD	Chicago O'Hare International Airport	Chicago	2,200,736	2.87
	U.S. total		76,581,137	42.69

Source: Federal Aviation Administration

MAJOR AIR CARGO HUBS IN THE U.S.

According to the statistics provided by Airports Council International (ACI), U.S. airports MEM, ANC, SDF, MIA, LAX, ORD, and JFK ranked 2nd, 5th, 10th, 12th, 13th, 18th and 19th respectively by total cargo traffic in 2010. Their overall trends of annual cargo throughputs from 1996 to 2005 are presented in Figure 1, where the MEM airport has maintained its top position in the U.S. cargo transport since 1996. Because the MEM airport located slightly eastward of the U.S.'s centre, this geographic advantage can reduce delivery time to the east/west coast and help to compensate the time zone change of the flights heading to Europe or the east/west coast. Accordingly, a service agreement was signed between MEM and FedEx in 2001, which makes MEM become the main hub for FedEx (Prokop, 2002) and therefore the air cargo throughput of MEM increased significantly from 2002. Meanwhile, Federal Express and United Parcel Service have international sorting hubs at ANC's North Cargo Airpark because ANC is located within 9 hours of flying time to about 95% of the world's industrialized nations (Prokop, 2002). For that reason, majority of the cargo traffic at ANC is transhipment cargo (Ohashi et al., 2005). Comparing the statistics between 1996 and 2005, ORD and SDF enjoy 18.89% and 32.59% growth respectively. On the other hand, the cargo throughputs of MIA, LAX, and JFK remained relatively stable during the period of 1996 to 2005.

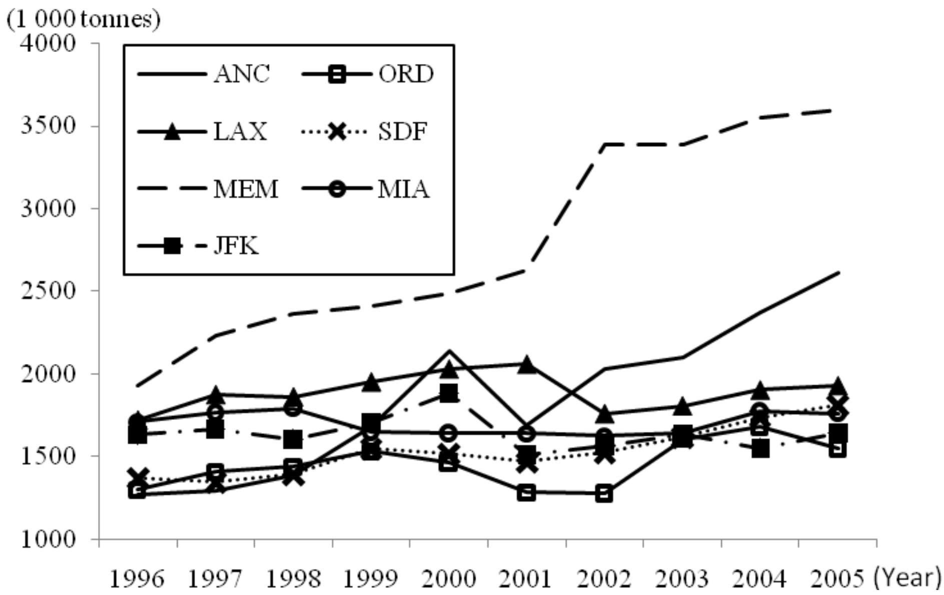
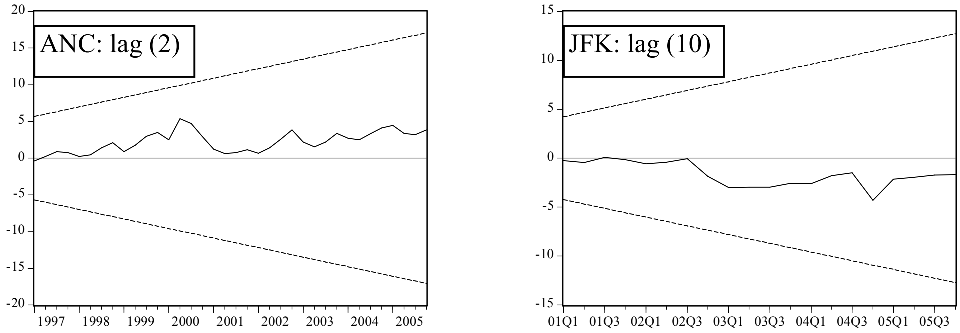


Figure 1: US main airports' cargo throughput from 1996 to 2005

To examine whether there exists structural changes of cargo throughput data for our target air hubs, the cumulative sum of the recursive residuals (CUSUM) were also analyzed in Figure 2. The null hypothesis of CUSUM test assumes that all coefficients in the error correction model of cargo throughput are stable. If the plot of CUSUM statistics lies within the critical bounds of 5% significance level, the null hypothesis cannot be rejected and therefore the model structure remains stable. According to the plots of CUSUM statistics shown in Figure 2, the CUSUM values of MEM, ANC, SDF, MIA, LAX, ORD, and JFK do not exceed the critical bound lines at 5% significant level during the period of 1996 to 2005. In other words, there are no structural changes for the cargo throughput data of our investigated airports. Therefore, we don't need to divide our observations into several periods for further Granger causality analysis because the model coefficients are consistent over time.



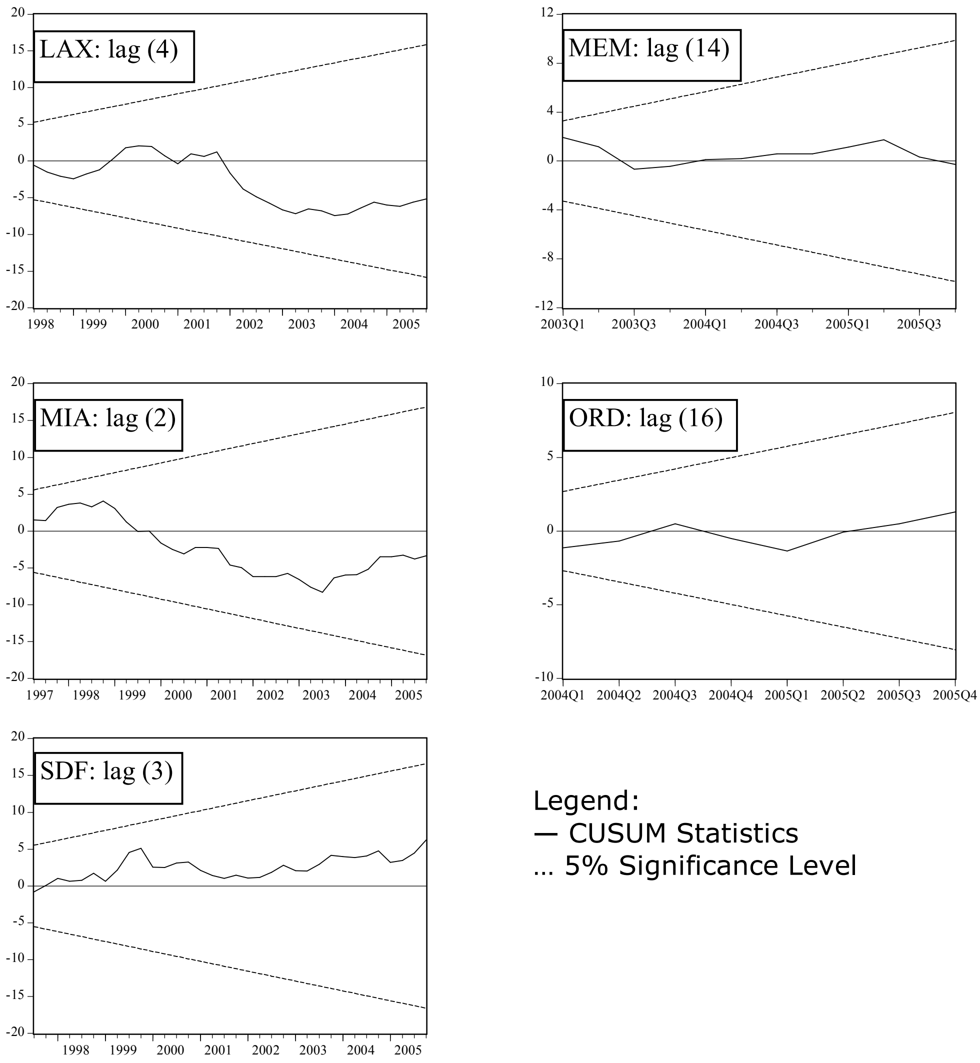


Figure 2: Plots of CUSUM tests for the U.S. airports

METHODOLOGY

To analyze the directed influences between U.S. air cargo hubs, the tests of unit root and Granger causality were conducted upon the observations of cargo throughputs. A unit root test is used to evaluate whether a time series data is stationary. This test should be investigated before the test of Granger causality because spurious regressions could occur if the data are non-stationary (Phillips, 1986). In this study, we applied Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) to judge whether a time series contains unit root(s). The null hypothesis of ADF test is that the time series is a non-stationary process. The critical values for the ADF t-statistics were adopted from the summarized tables of MacKinnon (1996). We denote I(d) as a non-stationary process whose first difference has to be applied d times to make the process stationary. Therefore, time series process is stationary if d = 0. Based on the results of unit root, difference transformations were applied to make sure that all time series are stationary before we conducted the Granger causality.

Suppose that X_t and Y_t represent the transformed cargo throughput data of airport X and airport Y respectively at time period t. Pairwise Granger causality tests on X_t and Y_t were based on the following bivariate regressions:

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{j=1}^{m} \beta_j X_{t-j} + \varepsilon_t \tag{1}$$

$$X_t = \alpha'_0 + \sum_{i=1}^{n} \alpha'_i X_{t-i} + \sum_{j=1}^{n} \beta'_j Y_{t-j} + \varepsilon'_t \tag{2}$$

where α_0 and α'_0 are constants, ε_t and ε'_t are disturbance terms with mean zero, and m and n are lag lengths enough to make disturbance terms white noise. The Wald F-test was used to detect the Granger causality relationships. The null hypothesis of Granger causality test in Equation (1) is that all of the coefficients β_j are zero. Airport X does not Granger-cause Y if this null hypothesis is not rejected. Similarly, the null hypothesis of Granger causality test in Equation (2) is that all of the coefficients β'_j are zero. If this null hypothesis is not rejected, it implies that Y does not Granger-cause X. Meanwhile, if X Granger-causes Y and vice versa, it is said that feedback relationship exists between airport X and airport Y.

FINDINGS OF DIRECTED INFLUENCES

Our samples include the quarterly cargo throughputs of the MEM, ANC, LAX, SDF, MIA, JFK, and ORD airports. Forty observations spanning over the period of 1996:1-2005:4 were collected for each airport from ACI's Worldwide Airport Traffic Report. Before evaluating the causality relationships, unit root test was conducted first to examine the stationary property of series data. Table 2 summarizes the results of ADF for the unit root processes of cargo throughputs. Because the hypotheses of non-stationary were rejected for the first-difference of ANC, JFK, MIA, SDF, LAX, and ORD at 5% level of significance, these air hubs are described as integrated to order 1 or be denoted as I(1) group. On the other hand, only the cargo throughput process of MEM belongs to the I(2) group.

Table 2: Results of ADF unit root tests

Group	Airport
Group 1: I(1)	ANC, JFK, MIA, SDF, LAX, ORD
Group 2: I(2)	MEM

After the differences transformations on I(1) and I(2) groups, we applied the Granger causality test to identify the causal relationships between cargo hubs based on the models of Equation (1) and (2). Table 3 only shows the Granger test results with significant F-statistics, which indicate the rejection of no causality hypothesis at 10%, 5%, and 1% significance levels. Our findings indicate that LAX not only Granger causes ANC, JFK, and SDF at the 5% significance level but also Granger causes MIA and ORD at the 1% significance level. Meanwhile, Granger causality relationships exist from MEM to ANC, MIA, SDF, and LAX. In addition, MIA not only Granger causes ANC and LAX at the 5% significance level but also Granger causes MEM and SDF at the 1% significance level. Furthermore, there exist Granger causality relationships from ORD to JFK, MEM and MIA. However, SDF only Granger causes ANC at the 1% significance level. Similarly, JFK only Granger causes MEM and SDF at the 5% and 10% significance levels respectively.

Table 3: Results of Granger causality between U.S. major airports

H_0 (null hypothesis)	F-statistics	P-value
LAX does not Granger Cause ANC	4.190	0.021**
LAX does not Granger Cause JFK	4.139	0.047**
LAX does not Granger Cause SDF	4.892	0.014**
LAX does not Granger Cause MIA	9.563	0.000***
LAX does not Granger Cause ORD	4.074	0.009***
MEM does not Granger Cause ANC	2.442	0.085*
MEM does not Granger Cause MIA	2.724	0.063*
MEM does not Granger Cause SDF	4.479	0.011**
MEM does not Granger Cause LAX	9.935	0.000***
MIA does not Granger Cause JFK	2.267	0.082*
MIA does not Granger Cause ANC	4.696	0.016**
MIA does not Granger Cause LAX	3.331	0.019**
MIA does not Granger Cause MEM	5.560	0.004***
MIA does not Granger Cause SDF	7.841	0.002***
ORD does not Granger Cause JFK	2.449	0.064*
ORD does not Granger Cause MEM	12.672	0.013**
ORD does not Granger Cause MIA	3.263	0.045**
SDF does not Granger Cause ANC	5.144	0.003***
JFK does not Granger Cause SDF	2.542	0.075*
JFK does not Granger Cause MEM	2.846	0.039**

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

If we translate Granger causality relationships into the concept of directed influences, Figure 3 depicts our findings from the perspective of U.S. cargo market. Most relationships of U.S. airports are unidirectional influences except MEM-MIA and MEM-MIA. That is, there exist bi-directional influences between MEM and MIA. Besides, ORD and JFK Granger-cause the cargo throughputs of MEM. Our findings also indicate that there exist unidirectional influences from ORD and LAX to MIA while LAX can be predicted from MEM besides MIA. In addition, the throughputs of JFK, LAX, MEM, and MIA Granger-cause the throughput of SDF. Furthermore, the throughput of ANC can be estimated by the observation from MIA, MEM, SDF, and LAX.

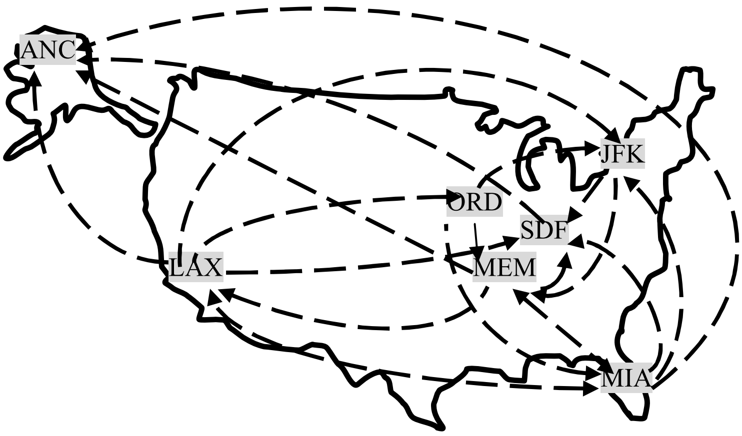


Figure 3: Directed influences of cargo throughputs between U.S. air hubs

CONCLUSIONS

To explore the directed influences between the major U.S. airports, this study applied the approach of Granger causality upon the observations of cargo throughputs. Our findings can help policy makers to select useful explanatory variables for the predictions of cargo throughputs. For example, MIA, SDF, MEM, and LAX are good explanatory variables for the cargo throughput prediction of ANC because of their Granger causality relationships. Future research can apply our results also to develop other econometric approaches such as vector autoregressive models to further understand the equilibrium and short-term dynamics between air cargo hubs. In addition, impact source of shocks between airports and the forecast error variance decomposition can be further investigated from the standpoint of time series methodology.

REFERENCES

- Batchelor, R., Alizadeh, A., Visvikis, I., 2007. Forecasting spot and forward prices in the international freight market. International Journal of Forecasting 23, 101-114.
- Button, K., Taylor, S., 2000. International air transportation and economic development. Journal of Air Transport Management 6, 209-222.
- Chang, Y.-H., Chang, Y.-W., 2008. Air cargo expansion and economic growth: Finding the empirical link. Journal of Air Transport Management doi:10.1016/j.jairtraman,2008.09.016.
- Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association 74, 427-431.
- Granger, C.W.J., 1969. Investing causal relations by econometric models and cross-spectral methods. Econometrica 37 (3), 424-438.
- Humphreys, I., Francis, G., 2002. Policy issues and planning of UK regional airports. Journal of Transport Geography 10, 249-258.
- Lahiri, K., Yao, V.W., 2006. Economic indicators for the US transportation sector. Transportation Research Part A 40, 872-887.
- MacKinnon, J.G., 1996. Numerical distribution functions for unit root and cointegration tests. Journal of Applied Econometrics 11, 601-618.
- Matsumoto, H., 2004. International urban systems and air passenger and cargo flows: Some calculation. Journal of Air Transport Management 10, 241-249.
- Ohashi, H., Kim, T.S., Oum, T.H., Yu, C., 2005. Choice of air cargo transshipment airport: an application to air cargo traffic to/from Northest Asia. Journal of Air Transport Management 11, 149-159.
- Ozbay, K., Ozmen-Ertekin, D., Berechman, J., 2007. Contribution of transportation investments to county output. Transport Policy 14, 317-329.
- Phillips, P.C.B., 1986. Understanding spurious regressions in econometrics. Journal of Econometrics 33 (3), 311-340.
- Prokop, D., 2002. The logistics of air cargo co-mingling at Ted Stevens Anchorage International Airport. Journal of Air Transport Management 8, 109-114.
- Zhang, A., 2003. Analysis of an international air-cargo hub: The case of Hong Kong. Journal of Air Transport Management 9, 123-138.

IMPACTS OF AUTONOMOUS COOPERATION-ENABLING TECHNOLOGIES ON THE CORPORATE VALUE OF LOGISTICS ENTERPRISES

Michael Hülsmann[1], Christoph Illigen[2], Philip Cordes[3]
[1]Michael Hülsmann (m.huelsmann@jacobs-university.de), [2]Christoph Illigen (c.illigen@jacobs-university.de), [3]Philip Cordes (p.cordes@jacobs-university.de)
Jacobs University Bremen

Acknowledgement
This research was supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes - A Paradigm Shift and its Limitations".[6]

INTRODUCTION

The idea of autonomous cooperation seems to offer chances to improve efficiency and robustness of logistics processes (ten Hompel 2007). It is based on decentralised decision-making of self-ruling logistics objects that interact in heterarchical and non-deterministic systems (Windt & Hülsmann 2007). For an implementation, new technologies like RFID tags or self-controlling sensor networks are required. These technologies contribute to a higher degree of autonomous cooperation. These technologies are still under development and it has not been causally reasoned yet, if and how the implementation and utilisation of suchlike technologies in logistics processes affects returns and risks of the related companies financially (Hülsmann et al. 2010). Besides a real-option theory-based construction of a logical link between autonomous cooperation and control and the corporate value (Wycisk 2009), it remains still empirically unproved, whether autonomous cooperation-enabling technologies increase or decrease the corporate value of a logistics service providing company.

To answer this question, an empirical study on the development of share prices of 40 logistic service providing companies listed at the stock exchange as an exemplarily marker for the corporate value in dependence on announcements about technologies related to autonomous cooperation and control is conducted. This study compares three different groups of data for 2004 – 2010: the share price development (1) in the whole period without any announcements about technologies in general or related to autonomous cooperation and control, (2) on days directly after announcements about technologies in general, and (3) on days directly after announcements about autonomous cooperation-enabling technologies. Thereby, the share price development shall serve for two purposes: First, the statistical mean will be used as an indicator for effects on the corporate value; the more the share price increases the more positive is the effect of an announcement and vice versa. Second, the standard deviation will be utilised as an indicator for risks; the higher the fluctuation of the share price the higher the associated risk and vice versa. This study allows estimating value and risks effects according to announcements that indicate a planned or completed implementation of technologies in general and autonomous cooperation-enabling technologies in particular.

Besides an introduction in **Section 1** and conclusions in **Section 5** the paper comprises three major sections: **Section 2** will present the concept of autonomous cooperation and deduces the problem of value orientation for the decision-making about investments in technologies for Logistics Service Providers (LSP). A methodology for the empirical study will be carried out in **Section 3** by collecting relevant data (share prices and press announcements from 2004 – 2010) and assigning key indicators for this investigation (statistical mean and standard deviation). In **Section 4** the hypotheses will be

[6] A former version of this paper has been published as „Cordes, P.; Illigen, C.; Hülsmann, M.: Effects of Autonomous Cooperation-Enabling Technologies on the Growth of Share prices of Logistics Enterprises. In: Hülsmann, M. (ed.): Scientific Series: Research Contributions to Strategic Management, Vol. 27. Jacobs University, Bremen, 2011"

operationalized, tested and the results will be interpreted to gain insights to the research question.

AUTONOMOUS COOPERATION AS VALUE DRIVER FOR LOGISTICS SERVICE PROVIDERS

There is an increasing interest in the concept of autonomous cooperation and associated technologies. Examples for such technologies are RFID-tags (e.g. Ngai et al. 2008, Angeles 2005), sensor networks (e.g. Jedermann & Lang 2008, Jedermann et al. 2009) or even common internet-based tracking and tracing systems (e.g. van Dorp 2002, Stefansson & Tilanus 2000). They have in common that they increase the degree to which logistics objects are able to decide autonomously, decentralised from a central control entity and based on information that they got from other logistics objects through interactive activities. Hence, hierarchy levels are reduced and the possibility to forecast future developments of the respective logistics systems gets increasingly difficult up to impossible. Therewith, the following characteristics are constitutive for autonomous cooperation processes: autonomy, decentralised decision-making, interaction, heterarchy and non-determinism (Windt & Hülsmann 2007). Several effects of an increase of these characteristics have been already analysed, such as effects on the logistics system's robustness (Hülsmann et al. 2008b) or on its efficiency (Hongler et al. 2010). The results of the research on positive as well as negative effects of autonomous cooperation having an impact on the logistics systems performance do not provide concrete information about the effects on the corporate value of the respective logistics enterprise though. However, according to Bowersox, Closs and Stank (2000), the increasing importance of value-based management of logistics processes is one out of the "ten mega-trends that will revolutionise supply chain logistics" (Bowersox et al. 2000). Consequently, it would not be sufficient to base decisions about investments in autonomous cooperation-enabling technologies on insights about their effects on efficiency and robustness of logistics processes. Instead, suchlike decisions are rendered with a focus on the effects on financial management ratios such as the Economic Value Added (EVA) or the Market Value Added (MVA) (Bowersox et al. 2000). More general, investment decisions are rendered in the area of conflict between returns on and risks of investments (Arditti 1967). Hitherto research on robustness and efficiency indicates both positive and negative impacts of autonomous cooperation on rents, for example through an increased strategic adaptivity (Hülsmann et al. 2008a), and on risks, for example through missing compatibility with technologies of business partners (Hülsmann et al. 2010). However, no net effects have been observed up to now on which investment decisions can be based.

There is a high diversity of methods that enable autonomous cooperation (Windt et al. 2010). Consequently, there is also a high diversity of different technologies that increase the characteristics of autonomous cooperation of logistics processes. Additionally there are many different potential application fields of autonomous cooperation in logistics – from transport to production logistics. Therefore, it can be assumed that the outcomes and effects of a decision to invest in implementing autonomous cooperation-enabling technologies are individually different. Hence, no general statement can be deduced that reflect all individual outcomes and provides security for the rents and risks of associated investments to be expected. However, what can be done is to reveal the average of all the effects of different implementations of autonomous cooperation-enabling technologies on the corporate value and associated risks. Therefore, the first question that arises is, whether or not there is an influence at all of autonomous cooperation-enabling technologies on the rents and risks of logistics companies. Hence, the following hypothesis is the first to be tested in this paper:

H1: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then its economic value does not change.

Second, if hypothesis 1 can be rejected, the question arises, if the influence is positive or negative. In other words: Does the economic value increase or decrease? This corresponds to a positive respectively a negative effect on the rents of an associated investment decision. Hence, hypothesis 2 reads as it follows:

H2: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then its economic value does not increase.

According to March and Shapira (1987) *"(…) risk is most commonly conceived as reflecting variation in the distribution of possible outcomes (…)"* (March & Shapira 1987, p. 1404). A suitable indicator for risks of an investment is the resulting variation of the economic value. Hence, hypothesis 3 has to reflect the interrelation between the use of autonomous cooperation-enabling technologies and the variations of the economic value:

H3: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then the variations of the changes of its economic value are larger than without a change.

The verification of these three hypotheses provides insights into the average effects of an investment in autonomous cooperation-enabling technologies on rents (average growth of company value) and risks (variation of the company value's growth).

METHODOLOGY TO IDENTIFY VALUE EFFECTS OF AUTONOMOUS COOPERATION

The methodology of this study comprises three central parts for the estimation of an alteration of a logistics company's economic value, of an alteration of a logistics company's degree of autonomous cooperation and of the causal interrelationship: First, assumptions for the empirical framework. Second, the procedure for the data collection. Third, a development of suitable key indicators. The section continues next with the **assumptions:**

To estimate the economic value of a company, the share price of stock market listed companies can be utilised (Rapaport 1986). Following the market efficiency hypothesis (MEH) the value of all shares can be considered as an indicator for the company value at every point in time (Fama 1970). Accordingly, as the MEH assumes that all information is immediately available to all actors in a market an under or over evaluation is not possible (e.g. Franke & Hax 2004). However, several authors also mention that the MEH cannot be applied to real circumstances, since players in the market cannot act endlessly fast and not all information can be communicated immediately (Franke & Hax 2004). For example, the economy bubble in the beginning of the last decade demonstrates that overestimation of stock prices are not impossible (Kriegs & Diehm 2001). Additionally, information diffusion might be hampered due to information retention or media breaks in the communication process (Franke & Hax 2004). Verrechia (1979) demonstrate that in the case of a sufficient number of participants in the market reality is well approximated with the MEH (Verrecchia 1979). Consequently, the share price can be applied as an appropriate indicator for the company value:

Assumption 1: It is supposed that an upturn of cooperation's degree of autonomous cooperation influences the share prices of a company and the company value correspondingly.

To estimate an alteration of a logistics company's degree of autonomous cooperation (2), a way how to determine a change of this degree has to be developed. This paper follows the idea that the realisation of autonomous cooperation can be applied through implementing or increasing the utilisation of technologies enabling logistics objects to decide decentralised and autonomously as well as to interact with each other in a more and more heterarchical and non-deterministic system structure. Thus, it is likely if a company applies suchlike technologies that the degree of autonomous cooperation in its processes increases. Accordingly, the second assumption is formulated as follows:

Assumption 2: It is supposed that a logistics company's degree of autonomous cooperation will turn up when a company implements or extends the usage of a technology that enables autonomous cooperation in logistics processes.

Finally, the general causal interrelation between an application of autonomous cooperation-enabling technologies and share prices shall be operationalized. Following the MEH (available information influence the share price directly) it can be stated that (a) if the degree of autonomous cooperation influences a company's value and (b) this is reflected in the share price development (assumption 1) and (c) the degree of autonomous cooperation depends on the application of associated technologies (assumption 2), then announcements about an application of autonomous cooperation-enabling technologies will immediately affect the share price. Thus, the causal interrelation "announcement of autonomous cooperation-enabling technologies -> effect on share price -> effect on company value" can be applied. Accordingly the final assumption is:

Assumption 3: It is supposed that a logistics company's degree of autonomous cooperation will turn up when a company implements or extends the use of a technology that enables autonomous cooperation in logistics processes.

In conclusion, the share price is an adequate indicator for measuring effects of announcing an application of autonomous cooperation-enabling technologies on the share price of logistics companies. In other words: If suchlike technologies are applied and this is published, than the share price can be applied to estimate effects on the company value.

In order to reveal and investigate the interrelations the **relevant data** have to be collected and analysed. For collecting the required announcements of each investigated company from 2004 - 2010, the Dow Jones Factiva Database was used. It provides press reports from 28,500 sources covering 200 countries in 25 different languages including 900 newswires (DowJones & Company 2010). Therefore, it can be assumed that once information about the usage of autonomous cooperation-based technologies is released, it is nearly immediately available in the Factiva database. The database this study applies for the analysis is based on a three-step search examination. *The first step* is to seek the entire English speaking Factiva database by LSP company name and no else thematically restrictions. The result of this retrieval constitutes the entire information-base for the succeeding analysis. *The second step* is to filter thematically technology-related press reports (i.e. those addressing the usage of a technology). The result group will be used to check whether the potentially found effects on the company value are only due to the implementation or extension of usage of technologies in general without autonomous cooperation-related reports. For this purpose, a filter list based on conducted expert interviews was created containing commonly used tech terms in logistics (e.g. GPS, RFID or tracing). Additionally, a truncation system for enhancing matching was applied (e.g. synchronis*). *The third step* is to filter autonomous cooperation-related press reports out of the formerly identified technology-related ones. Hence, additional expert interviews were performed focusing on autonomous cooperation-related keywords (e.g. agent-based, communicate or autonomous). This list is a subset of the list with technology-related keywords and is also used with the truncation system. The data collection covers a representative group of 40 logistics companies and related information about utilisation of autonomous cooperation-enabling technologies as well as their share prices. In order to guarantee highest possible comparability, only companies listed at the same trading centre (i.e. Frankfurt Stock Exchange) were analysed reducing the total number of companies considered to 40. Additionally, as the share price development of a particular company depends on plenty of different factors, it is corrected for this investigation by the general market development. Thereby, just the change of a company related stock price independent from the market development can be obtained. Here, the "Deutscher Aktien Index" (DAX) was chosen, since it exhibits the 30 largest German stock market listed companies. The time span of this investigation covers the years 2004 - 2010, since autonomous cooperation is a relatively new concept and related technologies are still under development (Jedermann & Lang 2008). Accordingly, this analysis is based on the share prices of the 40 LSP listed at the Frankfurt Stock Exchange in the time span between January 2004 and September 2010. In order to be able to adjust the share prices to the DAX-development, it is firstly necessary to make them comparable. Hence, the DAX as well as each of the regarded company' share prices have to be normalised. For the normalised DAX/company I, the value X in time t is calculated as:

(1) $X_{DAX;t} = \frac{100}{X_{DAX;t-1}} \times X_{DAX;t}$ for all trading days at the Frankfurt Stock Exchange $t \in \{1 \dots n\}$ and $t_1 = 2004/01/02;\ t_n = 2010/09/30$.

(2) $X_{i;t} = \frac{100}{x_{i;t-1}} \times X_{i;t}$ for all companies $i \in \{1 \dots k\}, k = 40$ and for all trading days at the Frankfurt Stock Exchange $t \in \{1 \dots n\}$.

Of concern for this study is the growth G of each trading day, i.e. the difference between the normalised share price of company *i* in time *t* and the normalised share price of company i in time $t-1$. Hence, the resulting formula is:

(3) $G_{i;t} = X_{i;t} - X_{i;t-1}$ and for the normalised DAX (4) $G_{DAX;t} = X_{DAX;t} - X_{DAX;t-1}$

The correction to the general market development requires subtracting the growth of the DAX from the growth of the respective company i. The normalised and adjusted growth for company i in time t, which is the main value to be analysed, is therefore:

(5) $G_{I,adj;t} = G_{I;t} - G_{DAX;t}$

Having the information about how to collect and normalise the relevant data the next section deals with the description of the development of appropriate **key indicators** to analyse effects of relevant technical announcements on a company's value. In the case of a data sample with more than one growth rate it is reasonable to focus on the respective mean (μ) (defined as $\mu = \frac{1}{n}\sum_{i=1}^{n} x_i$) in order to obtain an average value. An increase of the variations of the economic value of a company can be represented by the standard deviation (σ) (defined as $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$) of the growth of the share prices (e.g. Johnson & Bhattacharyya 2011). First, the difference of the adjusted and normalised share prices' mean (μ) growth after respective events and their adjusted and normalised 'normal' mean growth over a certain time period without these events will be examined. Second, the difference of the standard deviation (σ) of the adjusted and normalised share prices' growth after respective events and their 'normal' standard deviation over a certain time period without these events will be compared. Therefore, it is necessary to convert the data into key figures that reflect the arithmetic means and standard deviations of the regarded trading days. Thereby, three disjunctive groups of trading days were considered:

Group a: All trading days of company i except those after a publication of technology-related (including autonomous cooperation-based technologies) press reports; in the following referred to as $n_{i,a}$.

Group b: All trading days of company i after a publication of technology-related (excluding autonomous cooperation-based technologies) press reports; in the following referred to as $n_{i,b}$.

Group c: All trading days of company i after a publication of autonomous cooperation-based technology-related press reports; in the following referred to as $n_{i,c}$.

Thus, the total amount of trading days of a company i n_i contains the three disjunctive groups a, b and c, which can be calculated as follows: $n_i = n_{i,a} + n_{i,b} + n_{i,c}$.

According to the given formulas of the mean and standard deviation, the key figures for all companies are calculated for the three disjunctive groups a, b and c. Thereby, the formulas are adjusted as follows for the mean and the standard deviation (here exemplary demonstrated for Group a):

(6) $\mu_{i;a} = \frac{1}{n_{i;a}}\sum_{t_{i;a}=1}^{n_{i;a}} G_{i;adj;t;a}$ for all companies $i \in \{1 \dots k\}, k = 40$ and for all regarded trading days at the Frankfurt Stock Exchange.

(7) $\sigma_{i;a} = \sqrt{\frac{1}{n_{i;a}}\sum_{t_{i;a}=1}^{n_{i;a}}\left(G_{i;adj;t;a} - \mu_{i;a}\right)^2}$

Correspondingly, the aggregated arithmetic mean of the normalised and adjusted growth of the open share prices of all the regarded companies $I = \{1 \dots k\}$ is calculated by the sum of all share prices on each trading day of each group for each company divided by the sum of all trading days of each group of all companies (exemplary executed for Group a):

(8) $\mu_{I;a} = \frac{\sum_{i=1}^{k}\left(\sum_{t_{i;a}=1}^{n_{i;a}} G_{i;adj;t;a}\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;a}=1}^{n_{i;a}} t_{i;a}\right)}$ (9) $\sigma_{I;a} = \sqrt{\frac{\sum_{i=1}^{k}\left(\sum_{t_{i;a}=1}^{n_{i;a}} \left(G_{i;adj;t;a}-\mu_{i;t;a}\right)^2\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;a}=1}^{n_{i;a}} t_{i;a}\right)}}$

EMPIRICAL VALIDATION OF VALUE EFFECTS OF AUTONMOUS COOPERATION

This section develops operationalized hypotheses considering the assumptions in Section 3 to make the general hypotheses in Section 2 accessible to an empirical validation:

$H1_1$: The mean (μ) and the standard deviation (σ) of the growth of the share prices from the days the information came out to the following trading days are not different from the mean (μ) and standard deviation (σ) of the normalised and adjusted growth of the share prices over a representative period.

$H2_1$: If information about the usage of autonomous cooperation-related technologies becomes available, the mean (μ) of the growth of the share prices from the publication day to the following trading days (adjusted by the general market development) is not higher than the normalised and adjusted mean (μ) of the growth of the share prices over a representative period.

$H3_1$: If information about the usage of autonomous cooperation-related technologies becomes available, the standard deviation (σ) of the growth of the share prices from the publication day to the following trading days (adjusted by the general market development) is not lower than the normalised and adjusted standard deviation (σ) of the growth of the share prices over a representative period.

Only 28 out of the 40 companies were considered, since the remaining 12 comprises fewer than 37 relevant press reports and thus the results could not be proven statistically valuable. Therefore, 28 companies have been analysed regarding individual means, standard variations and number of investigated trading days. For assessing the hypotheses $H1_1$, $H2_1$ and $H3_1$, the aggregated values for every group (Group a, Group b and Group c) have to be compared, since these values reflect the impact of announcements about an implementation of autonomous cooperation-enabling technologies for all considered companies. Thus, at first the aggregated means for all companies are compared:

$\mu_a = -0.0465; \quad \mu_b = -0.011; \quad \mu_c = 0.0143$

Correspondingly, the share prices growth is higher after announcements of technology-related press reports (Group b) and still higher after publications of autonomous cooperation-related press reports (Group c) in contrast to the regular share price growth. Next, in order to analyse effects on variations the standard deviations are given:

$\sigma_a = 2.6551; \quad \sigma_b = 2.7755; \quad \sigma_c = 2.833$

Again, the share prices variation is slightly higher after announcements of technology-related press reports (Group b) and still higher after publications of autonomous cooperation-related press reports (Group c) in contrast to the regular share price variation.

This indicates that $H1_1$ ($\mu_{I;a} = \mu_{I;c}$ and $\sigma_{I;a} = \sigma_{I;c}$ as well as $\mu_{I;a} = \mu_{I;b}$ and $\sigma_{I;a} = \sigma_{I;b}$) can be rejected, since the data displays differences, especially in the aggregated arithmetic means. Second, $H1_2$ ($\mu_{I;a} > \mu_{I;c}$ and $\mu_{I;a} > \mu_{I;b}$) and $H1_3$ ($\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$) have to be regarded differentiated. Although the data exhibits that the arithmetic mean of the share prices is higher on the autonomous cooperation-relevant days than on average, as well as than on days after information about general technologies got published, the differences are marginal. Hence, there are indicators that hypothesis $H1_1c$ can be rejected, but a clear rejection requires a larger amount of data and a deeper analysis about the significance of the differences. For the standard deviations, the data demonstrates also marginal differences. Moreover, both hypotheses cannot be rejected, since $\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$. Following the data and assumptions of the analysis, $H1_1$ can preliminary be rejected. With recourse to the corresponding general H1 that can be interpreted as: If the degree of autonomous cooperation is reflected in the usage of associated technologies, if this usage becomes public to the companies' shareholders in the form of press reports and if the share prices always reflect the true value of a company, then a change of the degree of autonomous cooperation affects a company's economic value. However, regarding the question if there is a positive or a negative effect on growth effects ($H1_2$) and the associated risks ($H1_3$), the data shows an unclear picture: Assuming the observed differences are significant and reflect a general pattern of a causal interrelationship between the use of technologies and the growth of share prices, the data indicates a positive correlation for the use of technologies in general and even stronger for the use of technologies that are associated with the concept of autonomous cooperation. Thus, H2 can be rejected. Moreover, the market seems to award companies that implement or increase the use of technologies in general. One reason could be that the use of technologies is seen as an indicator for being innovative or at least going with technological developments. The data also shows that the market seems to award companies even more that implement or increase the use of technologies that are associated with autonomous cooperation. The reason might also lie in the appraisal of traders that these technologies represent a new and innovative concept that, although not being diffused very much in the logistics practice, might promise additional benefits, such as higher robustness or efficiency of logistics processes. Subsuming, indicators have been found that autonomous cooperation does have a positive effect on the company value (reject H1 and H2) – but also increases the associated investment risks (do not reject H3).

CONCLUSIONS

The results demonstrate a slightly higher growth of the normalised and adjusted logistics companies' share prices, if the usage of autonomous cooperation-based technologies is announced. However, at the same time the related risks (variations) are also higher. Hence, the market expects an increased degree of autonomous cooperation leading to higher return on investments and concurrently to higher risks. However, the share price depends on various influencing factors not limited to the application of autonomous cooperation-enabling technologies. Although the general market development was considered, other possible influencing factors were not. The efficient market hypothesis is often criticised as being an unrealistic reflection of reality. Hence, the assumption that information of press reports is immediately (the next trading day) observable in the respective share prices does not necessarily reflect the truth. These potential limitations of the analysis' validity ascertain further research requirements: First, a deeper investigation of every press report to assign them to a positive, neutral or negative alteration of the degree of autonomous cooperation could help to improve the results. Additionally, a scaling of changes of the autonomous cooperation's degree should be elaborated to classify particular alterations. Second, the amount of both regarded companies and associated press reports can be increased to increase the probability that the (non-)rejection of a certain hypothesis would reflect the corresponding true causal interrelationship.

REFERENCES

Angeles, R. 2005, "RFID technology: supply-chain applications and implementations issues", *Information Systems Management,* vol. 22, no. 1, pp. 51-65.

Arditti, F.D. 1967, "Risk and the Required Return on Equity ", *The Journal of Finance,* vol. 22, no. 1, pp. 19-36.

Bowersox, D.J. & Closs, D.J. & Stank, T.P. 2000, "Ten mega-trends that will revolutionize supply chain logistics", *Journal of Business Logistics,* vol. 21, no. 2, pp. 1-16.

DowJones & Company 2010, "The Indispensible Resource for Research Professionals [Homepage of DowJones & Company], Available at http://www.dowjones.com/factiva/factivacom.asp [2010, 12/15].

Fama, E., F. 1970, "Efficient Capital Markets: A Review of Theory and Empirical Work", in: The Journal of Finance, vol. 25, no. 2, pp. 383-417.

Franke, G. & Hax, H. 2004, Finanzwirtschaft des Unternehmens und Kapitalmarkt, 5th edn, Springer, Berlin.

Hongler, M. & Gallay, O. & Hülsmann, M. & Cordes, P. & Colmorn, R. 2010, "Centralized versus decentralized control - a solvable stylized model in transportation ", *Physica A,* vol. 389, no. 19, pp. 4162-4171.

Hülsmann, M. & Grapp, J. & LI, Y. 2008a, "Strategic adaptivity in global supply chains—competitive advantage by autonomous cooperation", *International Journal of Production Economics,* vol. 114, no. 1, pp. 14-26.
Hülsmann, M. & Illigen, C. & Korsmeier, B. & Cordes, P. 2010, "Risks Resulting from Autonomous Cooperation Technologies in Logistics", in: Y. Li & W. Desheng (eds), *Proceedings of the 2010 IEEE International Conference on Advanced Management Science,* pp. 422-426.
Hülsmann, M. & Scholz-Reiter, B. & Debeer, C. & Austerschulte, L. 2008b, "Effects of autonomous cooperation on the robustness of international supply networks – contributions and limitations for the management of external dynamics in complex systems ", in: H. Haasis & H.J. Kreowski & B. Scholz-Reiter (eds), *Dynamics in Logistics – Proceedings of the 1st International Conference on Dynamics in Logistics. August 28th – 30th, 2007, Bremen, Germany.* Springer, Berlin, pp. 241-250.
Jedermann, R. & Lang, W. 2008, "The benefits of embedded intelligence – tasks and applications for ubiquitous computing in logistics ", in: C. Floerkemeier & M. Langheinrich & E. Fleisch & F. Mattern & S.E. Sarma (eds), *The Internet of Things – First International Conference, IOT 2008,* 26-28 March 2008, Zurich, Springer, Berlin, pp. 105-122.
Jedermann, R. & Ruiz-Garcia, L. & Lang, W. 2009, "Spatial temperature profiling by semi-passive RFID loggers for perishable food transportation", *Computers and Electronics in Agriculture,* vol. 65, no. 2, pp. 145-154.
Johnson, R., A. & Bhattacharyya, G., K. 2011, Statistics: principles and methods, Wiley, New York.
Krings, U. & Diehm, S. 2001, "Unternehmensbewertung in der New Economy – Alte Probleme bleiben", in: Der Schweizer Treuhänder, vol. 11, pp. 1133-1138.
March, J.G. & SHAPIRA, Z. 1987, "Managerial perspectives on risk and risk taking ", *Management Science,* vol. 33, no. 11, pp. 1404-1418.
Ngai, E.W.T. & Moon, K.K.L. & Riggins, F.J. & Yi, C.Y. 2008, "RFID research: an academic literature review (1995–2005) and future research directions", *International Journal of Production Economics,* vol. 112, no. 2, pp. 510-520.
Rapaport, A. 1986, Creating shareholder value: the new standard for business performance, Free Press, New York.
Stefansson, G. & Tilanus, B. 2000, "Tracking and tracing: principles and practice ", *International Journal of Technology Management,* vol. 20, no. 3-4, pp. 252-271.
van Dorp, K. 2002, "Tracking and tracing: a structure for development and contemporary practices", *Logistics Information Management,* vol. 15, no. 1, pp. 24-33.
Verrecchia, R., E. 1979, "On the Theory of Market Information Efficiency", in: Journal of Accounting and Economic, vol. 1, pp. 77-90.
ten Hompel, M. 2007, Internet der Dinge: Selbststeuernde Objekte und selbstorganisierende Systeme, Springer, Berlin.
Windt, K. & Becker, T. & Jeken, O. & Gelessus, A. 2010, "A classification pattern for autonomous control methods in logistics", *Logistics Research,* vol. 2, no. 2, pp. 109-120.
Windt, K. & Hülsmann, M. 2007, "Changing paradigms in logistics – understanding the shift from conventional control to autonomous cooperation and control ", in: M. Hülsmann & K. Windt (eds), *Understanding autonomous cooperation & control – the impact of autonomy on management, information, communication, and material flow.* Springer, Berlin, pp. 1-16.
Wycisk, C. 2009, Flexibilität durch Selbststeuerung in logistischen Systemen . Entwicklung eines realoptionenbasierten Bewertungsmodells, Gabler, Wiesbaden.

FINDING A GENERIC ALGORITHM FOR INTEGRATING VALUE-BASED OBJECTIVES AND LOGISTICS GOALS – OPERATIONALISATION OF ORDER PRIORITISING IN PRODUCTION CONTROL BASED ON CUSTOMER VALUE MANAGEMENT

Michael Hülsmann[1], Christoph Illigen[2], Katja Windt[3], Oliver Jeken[4]
[1]m.huelsmann@jacobs-university.de, [2]c.illigen@jacobs-university.de,
[3]k.windt@jacobs-university.de, [4]o.jeken@jacobs-university.de
Jacobs University Bremen

Acknowledgement
This research was supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations".

INTRODUCTION

One megatrend in logistics in recent years is a shift from traditional cost-oriented goals to a value-based management (Bowersox et al. 2000), which focuses on maximizing shareholder value instead of just minimizing the costs (Müller-Stewens & Lechner 2005, Straube et al. 2005). From a logistics perspective, this means giving more attention to the target punctuality and not only focusing on capacity utilization. However, there is still a missing link between logistics and the value-based management (Straube et al. 2005) hampering an integration of both perspectives. Thus, a successful and simultaneous integration of the postulates of both perspectives – those of logistics and those of value-based management – into the operations management seems to be difficult.

One way to connect logistics to the concept of value-based management is to integrate the customer value management (CVM) into logistics. This concept explicitly focuses on customers contributing the most to a company in terms of monetary value (Stirling 2000). This in turn contributes to the value-based management, since a concentration on more valuable customers increases shareholder value. By that integration, logistics goals (e.g. short throughput times or high machinery utilization (Nyhuis & Wiendahl 2008)) can be linked with those of the CVM (i.e. maximizing lifetime profit from a customer or increasing information exchange frequency with customers (Pease 2001)). Hülsmann et al. (2010) conceptualised the implementation of CVM into the logistics planning and control for which both goals settings (logistics and customer value) are considered concurrently. Thus, the goal settings can therewith be optimised simultaneously enabling companies to increase their shareholder value. However, this research is still on a conceptual level.

Therefore, the **central objective** of this paper is to develop an algorithm based on the approach of Hülsmann et al. (2010) to enable logistics companies to integrate the value-based management into real world logistics scenarios: **(1)** Sets of requirements for a formulation of the algorithm will be developed in order to have a profound basis for its development, which includes also a description of the conceptual approach of Hülsmann et al. (2010). **(2)** The algorithm itself – including functions and routines – will be formulated for generating a generic description of the processing steps for implementing in a dedicated programming environment. This also comprises a critical reflection on contributions and limitations regarding the applicability, the feasibility and the benefits of the algorithm in order to outline its implications for theory and practice.

INTEGRATING CUSTOMER VALUE MANAGEMENT INTO THE LOGISTICS GOAL SETTING

The conceptual approach of Hülsmann et al. (2010) for integrating logistics objectives (according to Nyhuis and Wiendahl (2008) e.g., high machinery utilization or high due date reliability) with those of the CVM (maximizing lifetime profit from the whole customer base (e.g., Pease (2001), Verhoef (2007), Gupta and Zeithaml (2006)) comprises two central concepts: The Autonomous Production Construction Cycle (APCC) and the CVM.

The **APCC** implements the idea of autonomous control to logistics manufacturing systems (Windt & Jeken 2009). The resulting autonomous logistics processes enable logistics objects (i.e. parts, containers) "*to process information, to render and to execute decisions on their own*" (Windt et al. 2008). Hence, the APCC is one potential approach to cope with new requirements to logistics (Scholz-Reiter et al. 2004) caused by nowadays logistics system's inherent complexity significantly influencing its performance (Bozarth et al. 2009), since the concept of autonomous control enables these systems to better handle these new requirements (Hülsmann & Grapp 2005). Accordingly, logistics objects in a job shop manufacturing system are able to route themselves through the production process without being steered by a central controlling entity. In the APCC a part decides autonomously about its next production step and thereby bases its decision on information about available product variants and customer orders. Each product is manufactured incrementally corresponding to an existent customer order pool, whereas each item receives regularly updated information based on a situational product variant – customer order combination. This loose allocation of items to customer orders provides additional flexibility for the system and can therewith contribute to a better logistics target achievement (Windt & Jeken 2009). Moreover, this approach allows for an integration of logistics objectives with e.g. those of the CVM, which can easily be integrated in the decision process of the logistics objects via e.g. rules in the corresponding logistics objects.

The **CVM** is an approach to analyse and increase customer value. The central idea is to achieve maximum lifetime profit from the whole customer base (Stirling 2000). It strives for these goals by increasing profits generated through customers and minimizing costs at the same time (Müller-Stewens & Lechner 2005). Thereby, the main goals of CVM according to Pease (2001) can be realized: (1.) the right customers (i.e. the most valuable) can be identified, (2.) the right relationship (no complaining or discussing customers) can be established, and (3.) the right retention towards customers (focusing on most important customers) can be kept (Pease 2001). There are two ways to increase customer value: First, increasing customer benefits like revenue per customer or frequency of customer orders. Second, decreasing customer costs such as negotiation or production costs (Müller-Stewens & Lechner 2005). By focusing on these elements the total value of a customer for a company can be increased. Thus, the CVM offers an appropriate way to investigate and improve the financial impact of a customer. By integrating these goals into the logistics objects as described above it is possible to link the CVM to the APCC. Consequently, logistics can be linked to a value-based management via the CVM. Exemplarily, a semi-finished part on the shop floor level would decide to allocate itself to a respective customer order where the customer order is ranked high, but eventually not the most urgent one.

As a combination of the proposed concepts APCC and CVM offers an opportunity to link logistics to a value-based management and therewith a value-orientation in logistics, this paper proceeds with the conceptual approach of Hülsmann et al. (2010). They elaborated an appropriate conceptual model for logistics combining both perspectives exhibiting two steps: First, establishing a ranking of customer orders. Second, release these ranked orders into the APCC. To create the ranking, they proposed the following three steps:

1. Identification of the constitutive characteristics of customer benefits and customer costs by conducting e.g. literature analysis or surveys,
2. formulating weightings in relation to the importance of every characteristic based on a pair-wise comparison, and
3. deducing a prioritization according to the overall score of each customer order by summing up the value of the weightings for each order (Hülsmann et al. 2010).

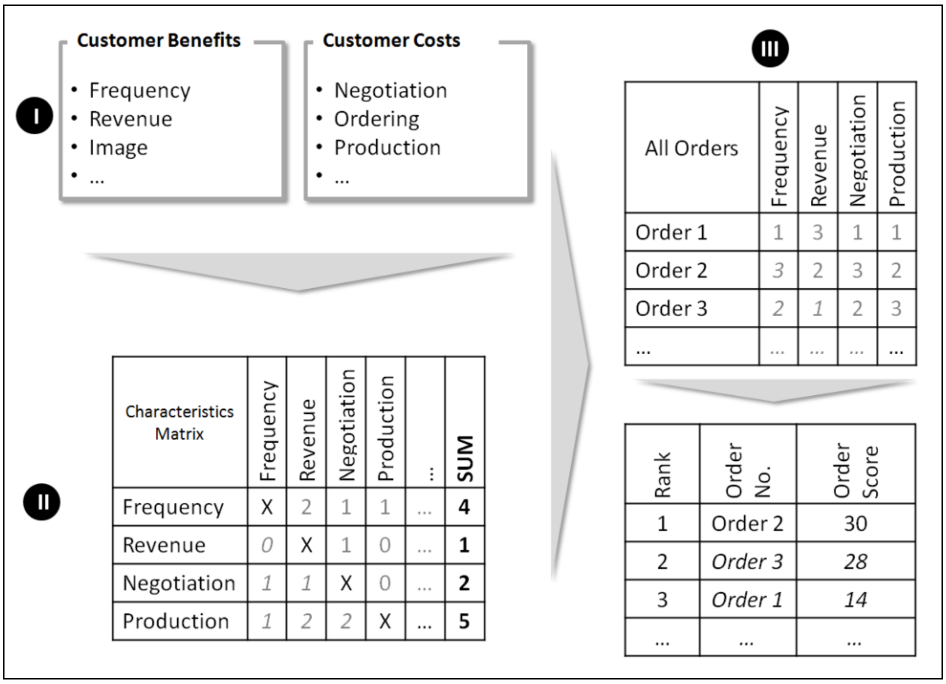


Figure 1: Pair-wise Comparison for building an Order Prioritization according to Hülsmann et al. (2010)

After having a ranking of customer orders, each order is released to the APCC and a backward scheduling is performed in order to determine the release date for the customer order. Thereby, the most important orders are released first according to their overall score leading to a better system performance from a value-based perspective (i.e. more valuable orders are treated prioritized). Additionally, if new orders are available for the APCC the ranking is updated and potentially more important orders than those already in the system are executed first and the whole system adjusts autonomously to the new order situation (e.g., if there is a part currently becoming a backlight without a fog lamp and a new and more important order exhibiting a fog lamp as the final product is released than the part would switch automatically to the new order and follow the required treatment steps for the new final product, if technically possible). Thereby, the integration of logistics and a value-based perspective takes place. However, since this approach is still on a conceptual level, the next step this paper takes on is to develop an algorithmic description of the whole procedure as a pre-condition for a later empirical validation (e.g., through simulation). Thus, the next section introduces a pseudo-code formulation of the APCC and the CVM including a description of both concepts. Further consequences are e.g. to redefine due date reliability or better to already consider important customers in prioritized due dates.

A PSEUDO-CODE BASED ALGORITHM TO IMPLEMENT THE CONCEPTUAL APPROACH FOR INTEGRATING FINANCIAL AND LOGISTICS GOALS

To illustrate how the integration of the APCC and the CVM is performed, this section is divided in three major parts: First, the product variant corridor as the underlying concept of the APCC is introduced in depth in order to fully understand the idea of the APCC. Then, the design logic for the APCC is introduced as pseudo code followed by the design logic for the CVM method. Thus, a concrete manual for an implementation is given.

The APCC concept is based on the idea of a **product variant corridor** that comprises all updated decision alternatives of a part, i.e. the combination of still possible product variants and currently unsatisfied customer orders. We define a part as a combination of different product features. Each of the features can have different feature specifications that define the final product variant. In order to obtain the product features the part has to run through different production process steps. At the start of the manufacturing process the part has no product variant specific features. During its production process the part gradually evolves towards a specific product variant by selecting the currently preferable alternative among the available different operations. What a preferable decision alternative is depends on the current demand situation represented by the orders in the order pool. Among other information such as due date the order contains the detailed specification of the requested product. In order to determine the elements of the product variant corridor for a part the subset {O*} of all {O} orders has to be identified. This subset {O*} of the set of all unsatisfied orders {O} fulfils the condition that all feature specifications of the part do either match the specification of the part or are zero, i.e. not specified yet. Due to the fact that the parts eventually progress to a specific product variant the subset {O*} decreases over the course of time. Only if additional customer orders enter the customer order pool the subset {O*} increases again.

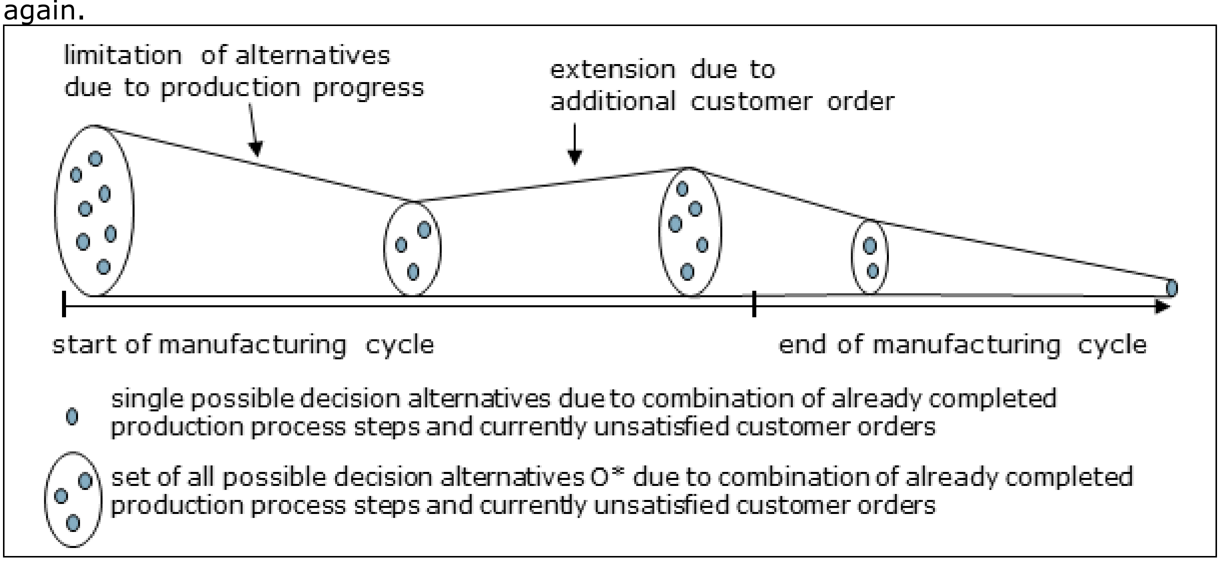


Figure 2 illustrates exemplary the development of the subset {O*} during the production process.

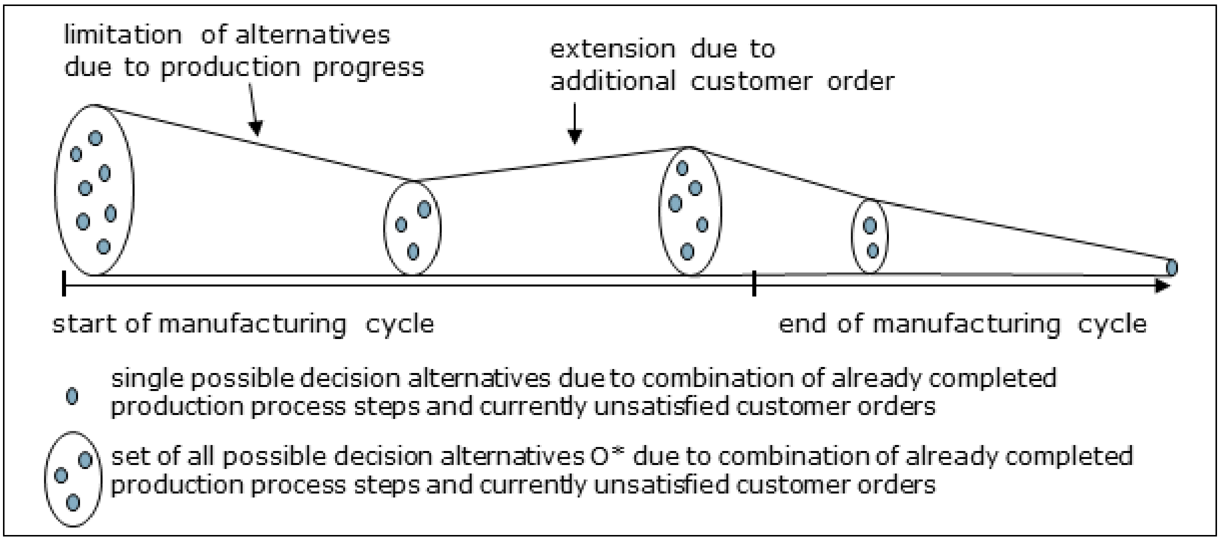


Figure 2: Product Variant Corridor (Windt, Jeken, 2009)

In order to determine which of the decision alternatives within the subset O* to choose the alternatives have to be evaluated according to suitable criteria. Simulation studies show that autonomous control methods perform quite good compared to classical scheduling heuristics depending on the dynamic and complexity of the production conditions (Scholz-Reiter et al. 2010). The so called *Queue Length Estimator* method for example allows parts after each production step choose the machine with the lowest workload to perform the next operation step. This method delivers shorter throughput times than classical scheduling heuristics for dynamic and complex production environments.

Apart from the routing related decision rules different dispatching rules can be applied at each individual work station. A huge variety of different dispatching rules has been researched over the past decades, of which some are capable to produce optimal schedules in specific production environments or are at least competitive heuristics (Pinedo 2008). A very well known rule is the *Earliest Due Date* rule, which sorts the parts at a machine in descending order of the due dates. This rule obviously aims at minimizing the lateness i.e. it increases the logistics target due date reliability. As the APCC allows for a loose and situational allocation of parts to customer orders the parts do not need to get sorted in the work station buffers, but they choose the order they aim for according to its due date. After these logistics related criteria have been applied to evaluate the available decision options it can be the case that more than one customer order fulfils them. Then it is necessary to refine the subset of feasible options by the application of further criteria, these can be other logistics related criteria depending on the overall company target system. The CVM approach offers a way to select the most beneficial customer orders for the company.

The pseudo code below shows first the generic **decision logic for the APCC**. Based on an initial set of orders (line 1), the algorithm reads the feature list for all parts (line 2-4). It compares the current production state of the actual part *i* with the current orders in the order pool {O} (line 5-7) and puts them in the candidate list {O*} (line 8), if it can fulfil orders of the order pool. The candidate list {O*} represents the product variant corridor of the specific part at that very moment. In order to choose one of the candidates this list is then sorted according to the applied logistics criteria x (line 9). After that the first entry of the candidate list is copied to the options list (line 10). If there are more than only one option i.e. there are candidates with the same logistics target achievement, all the orders that fulfil the criteria x are put in the options list $\{O^{*x}\}$ (line 11-15). If the options list contains more than one element (line 16), the one with the highest order score based on the CVM approach gets selected and fulfils the order (line 17). That is where the CVM is integrated into the APCC: If more than one part can fulfil a particular order at one point in time, the order comprising the highest customer value is served first. The order scores of all orders thereby get computed for each new order that enters the order pool {O}. Thus, new orders are considered as soon as they enter the system. The algorithm to determine the order score for each individual order is shown in Figure 4. If the very unlikely case of identical order scores occurs based on the CVM (line 18) the order with the earliest release date i.e. the one which is the longest in the production system is picked.

```
1: initial situation: setup order ranking {O}
2: for (i=1; i≤#parts; i++)
3:      for (n=1; n≤#features part_i; n++)
4:              get feature_list[n]
5:      for (j=1; j≤#orders; j++)
6:              for (k=1; k≤#orders; j++)
7:                      if (f_{i,n}=f_{i,k})
8:                              put in candidate_list                  % {O*}
9:      sort candidate_list (ascending to x)
10:     put candidate_list[1] in options_list
11:     for (l=1; l≤#elements candidate_list; l++)
12:             if (candidates_list[l]=candidates_list[l-1]
13:                     put candidates_list[l] in options_list
14:             else
```

```
                    break                                        % {O*^x}
    if (#elements options_list>1)
            select max order score of options_list
                    if #elements max order score of options_list>1
                            select longest in system
```

Figure 3: Pseudo Code for Autonomous Production Construction Cycle Decision Logic

The **design logic for the CVM** to determine the CVM scores of the orders follows the approach described in section 2. First all customer benefits and customer costs (cb/cc) are updated if any changes occurred (line 1). If there are more than one cb/cc criteria (line 2), a pairwise comparison is conducted in order to weight the different criteria (line 3-16). Each cb/cc criteria is compared with all others in a matrix. The diagonal of the matrix contains no weighting (line 6). If the criterion i is more important than the criterion j the weighting is set to 2 (line 9). If the criteria are of the identical importance the weighting is set to 1 (line 11). If the criterion i is less important than the criterion j the weighting is set to 0 (line 13). In order to compute the weighting factor for each cb/cc criteria the single values are summed up (line 14-16).
In order to normalize the CVB order scores the algorithm searches for the maximum value of all weighting factors (line 17-21) and divides every order score by the maximum value (line 22-23). To compute the final CVM order score for each order the algorithm multiplies the normalized weighting factor with the row sum of the order score (line 24-26) and puts the final value in the customer value list (line 27). Finally the customer value list gets sorted (line28) and is then released to the APCC for further production.

```
1: update cb/cc list (if applicable)
2: if (count (cb/cc) > 1
3:      for (i=1; i≤#cb/cc;i++)
4:              for (j=1; j≤#cb/cc;j++)
5:                      if (i=j)
6:                              cell_value[i,j]='x'
7:                      else
8:                              if (cb/cc_i>cb/cc_j)
9:                                      cell_value[i,j]=2
10:                             else if (cb/cc_i=cb/cc_j)
11:                                     cell_value[i,j]=1
12:                             else
13:                                     cell_value[i,j]=0
14:     for (i=1; i≤#cb/cc;i++)
15:             for (j=2; j≤#cb/cc;j++)
16:                     weight_i,j-1 += weight_i,j
17: for (k=1; k≤#cb/cc; k++)
18:     Max=O
19:     for (l=1; l≤#cb/cc; l++)
20:             if (O_l,k>Max)
21:                     Max=O_l,k
22:     for (m=1; m≤#O; m++)
23:             y=O_m,k/Max
24: for (n=1; n≤#0; n++)
25:     for (o=1; 0≤#cb/cc; o++)
26:             O_sum,n+=row_sum_o*y
27:             put O_sum,n to CV_List
28: sort CV_list (descending)
```

Figure 4: Pseudo Code for Customer Value Management-Ranking

CONTRIBUTIONS AND LIMITATIONS OF THE INTRODUCED ALGORITHM

The following table gives a brief overview about some selected contributions and limitations of the introduced algorithm from the last section:

Selected Contributions	Selected Limitations
- The algorithm offers a detailed manual for an integrated application of the APCC and the CVM to a simulation. - It is generic and applicable to different production logistics scenarios. - It is flexible regarding logistics goals and costumer benefits/customer costs.	- Finding a good initial situation (i.e. number if parts & orders in the system) for starting a simulation is difficult and not verified. - The algorithm does not consider sequence constraints between single treatment steps. - It assumes a fix number of treatment steps for every part.

Table 1: Contributions and limitations of the introduced algorithm

The algorithm introduced before offers some new potential for logistics scenarios by integrating the APCC and the CVM and thereby integrating logistics as well as value-based goals. Thus, logistics target achievement can be ensured and overall logistics system's performance can be improved by focusing also on financial aspects. To begin with, the algorithm provides a **detailed manual** for a practical implementation, since all implementation steps are given as pseudo code allowing a programmer to realise it as real programming code. Thus the algorithm can be transferred to e.g., a computational simulation for further analysis and investigations. Therewith, verification tools like logical tests for simulations can be applied to intensively test and verify the algorithm. Additionally, the algorithm is **generic** and therewith applicable to various logistics scenarios. This is achieved through omitting scenario-specific characteristics like machinery capabilities or capacities and concentrating on parts and orders. Hence, the approach can be tested in plenty environments and thereby be compared under changing circumstances regarding its performance. This enhances the validity of the algorithm and might reveal some further potential for improvements. Finally, the algorithm is **flexible** regarding logistics goals and considered customer benefits as well as customer costs. The reason is that first the logistics goals can be exchanged in a way that a system initially focusing on e.g., high due date reliability can switch to minimum processing time as a goal. Second, the list of the examined customer benefits and customer costs can be expanded or reduced during production due to changing characteristics of orders. It might turn out that some formerly considered benefits or costs are irrelevant they and can be excluded in the next ranking, as every time the ranking is rebuilt it is updated for all orders according to the current benefits and costs. In conclusion, this flexible adaptability to new requirements allows the algorithm to react appropriately to changes in the objectives of a system.

Beside the described contributions the algorithm also exhibits some limitations. First, finding a good **initial situation** for a simulation of the algorithm might be difficult, since there is no experience at the moment about good initial conditions for a particular environment. Furthermore, a good initial setup of one specific scenario could be suboptimal for the next scenario, since various parameters might change between them (e.g., number of orders and parts). Thus, before starting a simulation a good way to find out appropriate starting parameters for the algorithm has to be identified via e.g., intensive parameter testing. Moreover, the algorithm **neglects sequence constraints** between single treatment steps, as this is omitted in the pseudo code. This limits the method for a practical application, as these constraints (e.g., cleaning a part before painting) usually exist in real scenarios. Accordingly, by that the algorithm is unrealistic to a certain extend and this could be improved by simply adding this feature in a next release. Finally, the algorithm **assumes a fix number of treatment steps** for every part, since this is fixed in the code. This might also be unrealistic, since parts in reality could feature a different number of treatment steps (e.g., a reflector containing a regular light and a fog lamp has more treatments steps to go through than a reflector without a fog lamp). This could also be added as a feature of the algorithm in the future to make it more realistic.

Further contributions and limitations might be revealed during implementation: For example, potential bottle necks in a job shop scenario could be identified throughout applying this method. On the contrary, since the method applies the concept of autonomous control, it might encounter the threat that it runs into local optima like autonomously controlled systems might do (Hülsmann et al. 2010).

CONCLUSIONS

This paper **intends to develop an algorithm** based on the approach of Hülsmann et al. (2010) in order to enable logistics companies to integrate the value-based management to real world logistics scenarios. The **main contribution** towards the described concept is that it offers a clear and in-depth description of how to integrate the APCC and the CVM, which is a precondition for a practical application. Thus, the designed approach of Hülsmann et al. (2010) can be tested under realistic circumstances: Logisticians can utilise the idea of integrating the APCC and the CVM for a simulation. Thereby, they can answer the question, whether an integration of both goal settings in their particular scenario is beneficial: It is also possible to test various parameterisations of their goals and to examine the effect of changes in weightings and goals settings. However, the concept has **remaining limitations**, which has to be considered. The algorithm excludes some facts from reality like sequence constraints or a changing number of treatment steps for parts during production. Additionally, the behaviour of the algorithm regarding parameterization and changing scenarios is unknown. Hence, a testing in different setups and under various conditions might help to estimate the overall quality of the algorithm.

Therefore, **further research** should focus on the revealed limitations and add the feature of varying treatment steps per part as well as the fact of sequence constraints to the algorithm. A simulation of a particular logistics scenario should also be performed in order to further examine the method in a realistic scenario. Finally, a procedure to automatically identify and weight qualitative variables of customer benefits and customer costs might further increase the quality of the algorithm.

Following **practical implications** of the developed algorithm can be named: Through the loose allocation of parts to orders and the possibility to change assignments during production the whole system becomes much more flexible. This allows reacting faster to changes and thus the logistics system’s and processes’ robustness is likely to be increased. If too many reallocations can also have a negative impact on the overall performance is still an open question, which needs further research attention. Additionally, through the realisation of the concept of autonomous cooperation to logistics scenarios by applying the given algorithm logisticians are enabled to cope with highly dynamic and complex systems in situations where common heuristics come close to their limits.

REFERENCES

Bozarth, C.C., Warsing, D.P., Flynn, B.B. & Flynn, E.J. 2009, "The impact of supply chain complexity on manufacturing plant performance", *Journal of Operations Management,* vol. 27, no. 1, pp. 78-93.

Bowersox, D.J., Closs, D.J. & Stank, T.P. 2000, "Ten mega-trends that will revolutionize supply chain logistics", *Journal of Business Logistics,* vol. 21, no. 2, pp. 1-16.

Gupta, S. & Zeithaml, V. 2006, "Customer Metrics and their Impact on Financial Performance", *Marketing Science*, vol. 25, pp. 718 – 739.

Hülsmann, M. & Grapp, J. 2005, "Autonomous cooperation in international-supply-networks – the need for a shift from centralized planning to decentralized decision making in logistic processes", *Innovations in Global Supply Chain Networks: proceedings of the 10th ISL conference,* K.S. Pawar (ed.), ISL, Lisbon, pp. 243–249.

Hülsmann, M., Windt, K., Illigen, C. & Jeken, O. 2010 "Value based order prioritizing in production control – integrating customer value management into the logistics goal-setting", In: K.S. Pawar & C.S. Lalwani (eds.), *Proceedings of the 15th International*

Symposium on Logistics. Configuring Next Generation Supply Chains, Kuala Lumpur, Malaysia, pp. 250-258.
Lechner, G. & Müller-Stewens, C. 2005, "Strategisches Management: Wie strategische Initiativen zum Wandel führen", Der St. Galler General Management Navigator, 3rd edition, Schäffer-Poeschel, Stuttgart.
Nyhuis, P. & Wiendahl, H.P. 2008, *Fundamentals of production logistics: theory, tools and applications,* Springer, Berlin.
Pease, J. 2001, *Customer value management - new techniques for maximizing the lifetime profitability of your customer base,* Business Objects.
Pinedo, M. 2008, *Scheduling: theory, algorithms, and systems,* Springer, New York.
Scholz-Reiter, B., Windt, K. & Freitag, M. 2004, "Autonomous logistic processes: New demands and first approaches", *Proceedings of the 37th CIRP International Seminar on Manufacturing Systems*, ed. L. Monostori, Hungarian Academy of Science, Budapest, Hungaria, pp. 357–362.
Scholz-Reiter, B., Rekersbrink, H. & Görges, M. 2010, "Dynamic flexible flow shop problems - scheduling heuristics vs. autonomous control", *CIRP Annals - Manufacturing Technology,* vol. 59, no. 1, pp. 465-468.
Stirling, M. 2000, "Customer value management", *Journal of Targeting, Measurement and Analysis for Marketing,* vol. 9, no. 2, pp. 174-184.
Straube, F., Danglmaier, W., Günther, W. & Pfohl, C. 2005, *Trends und Strategien in der Logistik: ein Blick auf die Agenda des Logistik-Managements 2010,* Deutscher Verkehrs-Verlag, Hamburg.
Verhoef, P.C. & van Doorn, J. & Dorotic, M.2007, "Customer value management: an overview and research agenda", *Marketing-Journal of Research and Management,* vol. 3, no. 2, pp. 51-68.
Windt, K., Böse, F. & Philipp, T. 2008, "Autonomy in production logistics: Identification, characterisation and application", *Robotics and Computer-Integrated Manufacturing,* vol. 24, no. 4, pp. 572-578.
Windt, K. & Jeken, O. 2009, "Allocation flexibility - A new flexibility type as an enabler for autonomous control in production logistics". Proceedings of the 42nd CIRP International Conference on Manufacturing Systems. Sustainable Development of Manufacturing Systems, Grenoble, FR, 2009, 8 pages, Proceedings published on CD without page numbers.

DEVELOPMENT OF A METHOD FOR IMPROVING THE WORKLOAD OF FLOW LINES WITH NON-LINEAR FLOW OF MATERIAL

Ayman Al Khateeb
Department for Industrial Engineering
Faculty of Mechanical Engineering
Ilmenau University of Technology, Germany

ABSTRACT
To avoid workload losses by bottlenecks in flow lines the capacity of assembly and manufacturing work stations has to be balanced. In principle, the distribution of the work amount at the processing stations in a production line must be made as equal as possible with the principle of SALBP. In the case of non-linear production systems, one finds very little guidance in the technical literature for the balancing of the station Workload. In this paper, a new strategy for improved distribution of the work amount on the stations in non-linear production systems is developed. In analogy to hydraulic systems, in which a relationship between the values of the cross-sectional areas of tubes and the flow rate exists, the processing times of stations in the flow lines before and after the network elements (splitting and merging elements) can be define in a similar way. Furthermore, the relationship between these processing times is analyzed and translated into formulas, and an algorithm is developed for the implementation of optimization.

Introduction
By the configuration and planning of production systems it is important to note that the processing stations must preferably work to full capacity, and any type of time losses must be reduced or eliminated. Fig. 1 shows a simple product network in which linear and non-linear production structures for manufacturing 6 products are shown. Taking fig. 1 into consideration, it can be seen that time losses and huge buffers are generated, if the processing times of stations on both sides of the network elements are not balanced. For the balancing of station workloads in the linear flow system the technical literature offers a lot of researches, such as (Scholl, 1999).

In this paper, a complete approach which defines the ideal situation of material flow in non-linear systems is developed. Main objectives of this method are the calculation of the ideal processing times of stations in each segment of the investigated production area, the determination of optimal numbers of stations in each segment and the presentation of suitable material flow strategies (transport means, quantity, etc.). Accordingly, the stations are optimally utilized, and the buffers between them are minimal busy. To develop the new approach, an analogy between the production systems and hydraulic pipes is made.

AIM AND PROCEDURES OF THIS WORK
The calculation of the processing times of stations in flow lines which are located on both sides of the network elements is based on the assumption of the ideal situation. No time loss or workload loss at the stations and the transport time between stations should occur and the time loss in the network elements would be negligible. To avoid wasting, the existing flow system should be optimized with the aim to get as close as possible to the ideal situation or even to achieve it.

With the help of an example, the hydraulic analogy and the improvements are realized. Here the model is searched, which includes a splitting and merging element (see manufacturing system for processing of raw material 2). The model is a production system with rework-loop (cp. (Al Khateeb, 2010). To simplify the method of optimization, a rough comparison between hydraulic pipes, which transport liquids –incompressible media - and the stations within a flow system, is made.

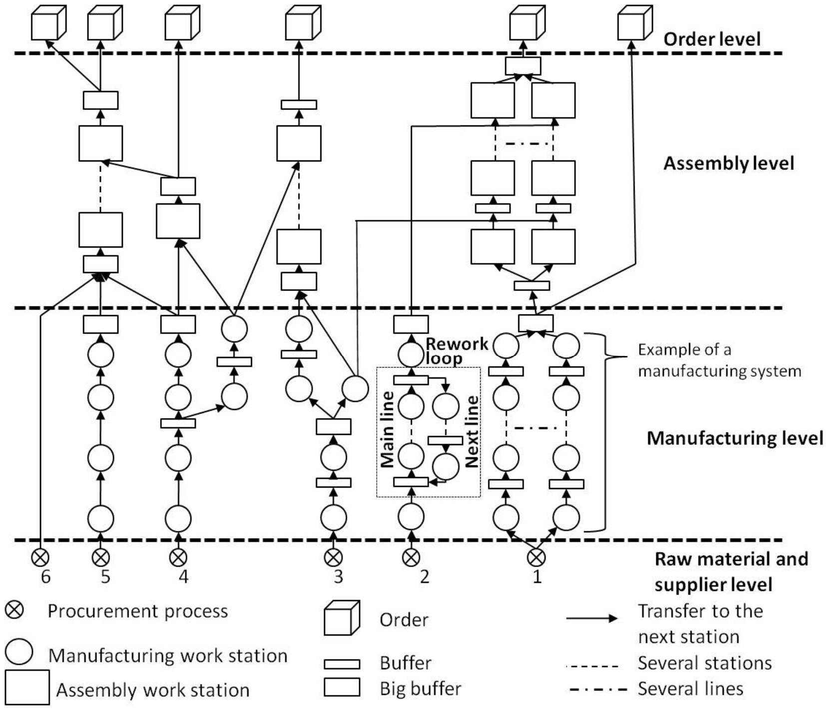


Fig. 1: Example of a product network

HYDRAULIC ANALOGY

Often the structures of the rework-loops are treated on the assumption that the averages of processing times of stations in the main and next line are equal (see (Helber, 1999)). To discuss this assumption, it is hereinafter assumed that the discrete material, such as a fluid, flows through a tube and the stations as valves and / or pumps[7] are used for conveying the medium to the next station. According to this idea, the materials are continuously processed at the stations (see (Helber et al., 2003)).

Referring to Fig. 2 and considering that the materials[8] can be melted in volume V, one can use the formulas of the flow rate Q in liquids (cp. (Wossog 2003)):
$Q = V / t$, t: duration of the study (flow)
$Q = c \cdot A$; c: mean flow velocity, A: cross-sectional area (CSA) of the tube

[7] In Fig. 2, only two stations as valves and pumps are shown. They are at the limits of the rework loop.
[8] Based on the same volume of materials

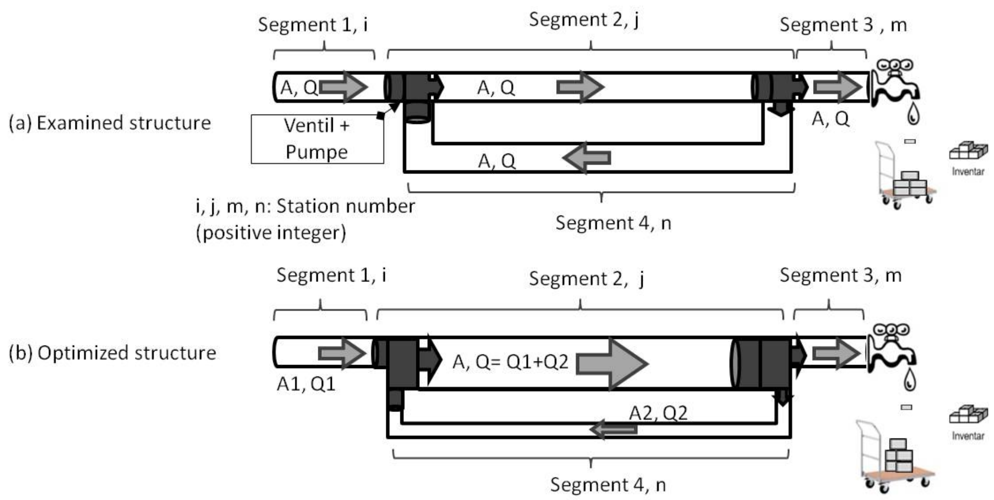


Fig. 2: Representation of the flow system as pipes and stations as valves

C is constant in different pipes; the CSA of the pipes are designed proportionally to Q. Fig. 2.b shows that the total flow rate Q for segment 2 is the sum of the individual Q1 and Q2. This means that A is equal to the sum of A1 and A2. If CSA in Fig. 2.a is not changed, the average flow velocity in the segment 2 increases and in segment 4 must decrease. The change in the flow rate can be achieved in the segments through the corresponding distribution of the work amount at the stations in the respective segment.
The flow velocity in hydraulic pipes corresponds to the production rate in the flow lines. The required processing time for producing a product in a flow system consists of individual work items. For economic or technical reasons, it can be assumed that this may be not divided (see (Kuepper et al., 2004). The goal is often the most efficient allocation of work elements at the stations of flow system. The increased production rate in a flow line requires a reduction of the maximum processing time of the station T_{max} by increasing the number of stations N, there is always:

$T_{max} \bullet N \geq \Sigma t$; Σt: The sum of working time of all work items (cp. (Kuepper et al., 2004))

MERGING AND SPLITTING ELEMENTS

The relationship between the arrival rates of the products before and after the splitting and merging elements are shown in Fig. 3 (see (Bolch et al., 2006)).
In flow systems, the splitting and merging flow -in the ideal case- can be represented as in Fig. 4. Equations of Fig. 3 are shown again in Fig. 4. The service rate μ is the mean number of materials which are processed in the station per unit time and it equals the inverse of the processing time of this station. $\mu = \frac{1}{T}$

Splitting equations: $\frac{1}{T_2} = p \cdot \frac{1}{T_1}$; $\frac{1}{T_3} = (1-p) \cdot \frac{1}{T_1}$

Merging equation: $\frac{1}{T_1} + \frac{1}{T_2} = \frac{1}{T_3}$

Replacing the reciprocals of the processing times in the formulas with CSA, one can get the formulas for calculating the CSA of pipes in Fig. 2. The last equations are used to calculate the nominal processing times of stations in a non-linear flow system.

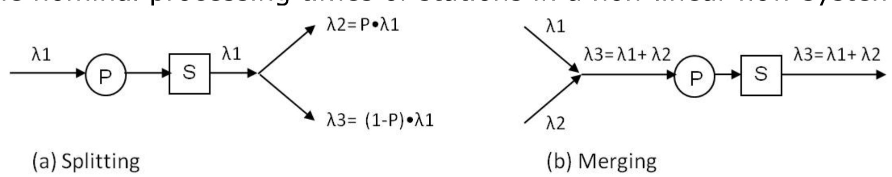


Fig. 3: Calculating the arrival rate bei splitting und merging elements

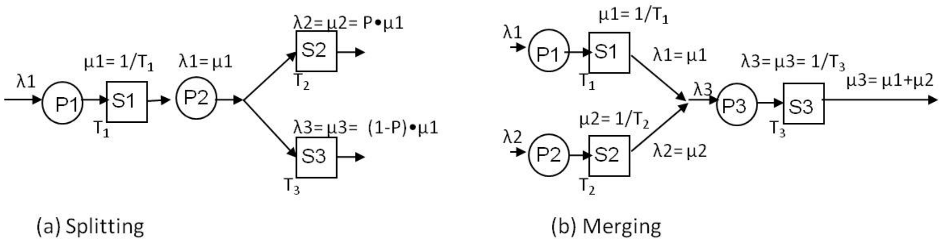


Fig. 4: Arrival rates and processing rates in the ideal case

ALGORITHM

In this section, a general approach is developed which represents the methodological steps that help to improve the configuration of flow system in the planning stage or redesign of existing systems. These steps can be summarized as follow:

1. Decomposition of the production structure in segments: Each segment is limited to two consecutive network elements and includes stations and buffers which have similar parts of processing time (working, blocked and waiting).
2. Calculation of the optimal processing times of stations in each segment T_{cop}. Since each segment itself can be regarded as flow line, where the averages of processing times of stations should be equal, it is sufficient to calculate the processing time of the first or last station in the segment[9].
3. Trying to change the number of stations in the examined segment. The goal is to achieve the mathematically optimal processing times T_{cop}. In the case of redesigning, the following rules must be considered:
   - If the examined processing time of segment T was less than T_{cop}, it would have reduced the number of stations in the segment. If the sum of processing times in the segment ΣT smaller than T_{cop}, the stations in the segment are to be combined in a single station, their optimal treatment time T_{op} is similar to value ΣT.
   - If $T > T_{cop}$, the number of stations would have to be increased in the segment[10] to increase the flow velocity at the end of it.
4. After carrying out the last steps, the optimal processing time Top must be reviewed and compared to the values T_{cop}. Depending on the deviation value, the following optimization methods are investigated, such as change in the method of transport between the stations and bottleneck-based control. The goal is to determine the appropriate transport means for the carriage of materials at the right time (JIT).

CONCLUSION

The successful planning of material flow in production systems must guarantee the production of the required product quantities at the appropriate time so that reduced stocks between the successive stations are targeted. To achieve these objectives, strategies and procedures have been presented in this paper for the investigation and optimization of complex networked production flow lines. To describe the behaviour of materials before, after and in the segments, equations were developed. With these equations, the ideal processing times of the stations are calculated. The better the examined values of the calculated parameters can be approximated, the greater the reduction in time or workload losses and buffer capacities will be. Furthermore, an algorithm is presented that interprets the detailed steps of the developed strategies in general.

REFERENCES

AL Khateeb, A (2010) "Optimierung von Fließproduktionssystemen mit Nachbearbeitungsschleifen", Tagungsband 6. WGTL, Hannover: Leibniz University.

[9] For simplicity, the term "processing time of the segment" can be used.

[10] It is expected that the work amount spreads over a larger number of stations, i.e., the stations are usually associated with several operations. However, this new distribution of the work amount must be technologically possible.

Bolch, G; Greiner, S; de Meer, H; S. Trivedi, K (2006) "Queueing networks and markov chains: Modeling and performance evaluation with computer science applications" Hoboken, NJ: Wiley-Interscience.

Helber, S (1999) "Performance analysis of flow lines with non-linear flow of material", Berlin [u.a.]: Springer.

Helber, S; Mehrtens, N (2003) "Exact analysis of a continuous material merge system with limited buffer capacity and three stations", Boston [u.a.]: Kluwer Acad. Publ.

Küpper, H; Helber S (2004) "Ablauforganisation in Produktion und Logistik", Stuttgart: Schäffer-Poeschel.

Scholl, A (1999) "Balancing and Sequencing of Assembly lines", Heidelberg: Physica-Verlag.

Wossog, G (2003) "Handbuch Rohrleitungsbau", Essen: Vulkan-Verlag

STAKEHOLDER-ORIENTED IMPLEMENTATION OF SUSTAINABILITY INTO SUPPLY CHAIN MANAGEMENT USING FUZZY LOGIC

Nina Vojdani, Mathias Knop
University of Rostock, Chair of Production Organisation and Logistics, Richard-Wagner-Str. 31, 18119 Rostock, Germany

ABSTRACT
This paper proposes a novel approach to integrate sustainability into supply chain management (SCM) taking the stakeholder perspective into account as stakeholders impose pressure on strategy definition, design, planning, and execution of sustainable supply chains. Special emphasis is placed on the introduction of stakeholder requirements into decision making process. The paper aims to present a fuzzy based approach to select sustainability measures to capture some degree of subjectivity of decision maker's preferences and perceptions. Furthermore, it appeals to initialise the implementation of identified sustainability measures in sustainable supply chain management (SSCM) context. In literature many sustainability measures are discussed, but so far no appropriate decision support approach is available that facilitates decisions on sustainability measures regarding stakeholder relevance. Thus, an approach is presented to overcome this shortcoming.

1 INTRODUCTION
The adoption of sustainability initiatives within SCM is increasingly concerned among companies worldwide. Surging energy and resource prices, growing public consciousness in environmental protection as well as opening possibilities to gain competitive advantages by adoption of sustainability measures within SCM have shifted the corporate focus from primarily economic objectives to an additional consideration of environmental and social issues. The supply chain as an extended perspective of sustainability management becomes increasingly important as focal companies are more and more frequently considered responsible for environmental and social problems at suppliers.

Conformity with stakeholders and thus legitimacy of sustainability measures and standards (such as ISO 14001, EMAS, and SA 8000) can be denoted as major prerequisite for SSCM [1]. Vojdani et al. pointed out that stakeholder conformity strongly determines the competitiveness of entire supply chains [2]. Therefore companies are challenged to determine important internal and external stakeholders and their requirements when integrating sustainability (measures) into SCM.

This paper proposes a novel approach to integrate sustainability into SCM taking stakeholders into account as stakeholders impose pressure on strategy definition, design, planning, and execution of sustainable supply chains. To ascertain relevant and stakeholder legitimised sustainability measures a fuzzy logic approach will be presented to select appropriate measures.

The paper is organised as follows: Section 2 presents a literature review on stakeholder management within SSCM. The proposed fuzzy logic approach is based on a SSCM framework which is introduced in section 3. The proposed fuzzy logic approach is presented in section 4 and a numerical example will be introduced in section 5. A summary and concluding remarks are outlined in section 6.

2 LITERATURE REVIEW
SSCM denotes an extension of SCM in effort to promote an integrative implementation of economic, environmental, and social objectives. According to Carter and Rogers, SSCM can be defined as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" [3]. Gold et al. give a brief overview about relevant literature on SSCM [4].

In the field of academic research the stakeholder perspective is often emphasised in SSCM context [1,3]. The stakeholder perspective accommodates the fact that companies do not act isolated of their environment. According to Freeman, "any group or individual who can effect or is affected by the achievement of the organization's objectives" can be considered as a stakeholder [5]. The basic idea underlying the stakeholder approach is the identification of stakeholders and consideration of their requirements in decision making processes. A sustainable supply chain network demands identification and implementation of appropriate measures which can be deduced from stakeholder requirements [2]. In this sense, stakeholders determine demand in terms of sustainability and companies react by definition of supply. Several stakeholder requirements in the context of SSCM have been identified, cf. [2].

Welford et al. analysed priorities for corporate social responsibility (CSR) [6]. "An integral part of CSR is the assumption of responsibility for the suppliers' production conditions within supply chain." [1]. The survey by Welford et al. examined business and their stakeholders' requirements in Hong Kong. Welford et al. identified important issues (good environmental performance, good health and safety practices, good corporate governance, codes of conduct on supply chains) and noticed differences regarding the importance of issues among different stakeholder groups.

In his dissertation about sustainability branding, Herman identified a comprehensive list of stakeholders that companies in the automotive and trading sector should consider within decision making [7]. Furthermore Herman ascertained the relevance of different stakeholders within both sectors.

Schaltegger et al. conducted an empirical analysis regarding the practical implementation of SSCM in German companies [8]. The authors state that many companies in Germany are convinced that external stakeholder pressure will increase in the future. Major stakeholders of DAX-companies (DAX - German share index) in the future will be: customers, consumers, government, shareholders, media, and authorities.

In addition to the explicit consideration of a company's stakeholders, another approach can be found in literature: the alignment and adoption of stakeholder legitimised standards [1]. The popular ISO 14001 standard, for instance, has low legitimacy among stakeholders [1].

In 2010, Vojdani et al. pointed out that stakeholders should be explicitly taken into account in SSCM decision making [2]. The authors emphasized that each company should identify relevant stakeholders and their requirements. A framework for SSCM has been introduced indicating the need of stakeholder specific integration of sustainability measures within strategy definition, design, planning, and execution of supply chains [2]. Therefore, companies should initialise stakeholder dialogues.

As shown, the stakeholder approach is widely used in SSCM literature. Researchers as well as practitioners stress the importance and amending effects of stakeholder dialogues (cf. [9]), but so far hardly any paper discusses how stakeholder can be integrated into SSCM decision making. Therefore, this paper introduces an approach to stakeholder-oriented implementation of sustainability into supply chain management using fuzzy logic.

3 FRAMEWORK FOR SSCM

In literature different SSCM frameworks (cf. [2,3,10]) are discussed and the number of publications in this research area is growing. To integrate sustainability into SCM a process-oriented framework is needed, therefore the approach by Vojdani et al. (cf. [2]) is further developed. According to this framework sustainability should be integrated in all phases of SCM (SC normative, SC (re-)design, SC (re-)planning, SC execution, SC monitoring and SC re-definition). The definition of mission, values, and objectives considering economic, environmental, and social issues is the initial step to integrate sustainability into SCM, cf. Figure 1. Due to the essential importance of stakeholders important stakeholder requirements should already be considered within the earliest steps of SCM. Sustainability issues are significant in all other phases of SCM, too. As part of the SC design phase the strategic SC network structure is defined and suppliers as well as buyers are selected. A sustainable SC network furthermore requires the consideration of products, processes as well as production and logistics systems, as they determine SC network design. The SC planning phase specifies strategic and SC design decisions. In this phase, procurement, distribution, traffic, and forms of collaboration are planned. All SC planning decisions should contribute to attain economic, environmental, and social targets. The SC execution phase primarily has control tasks to support the operational implementation of sustainability. A monitoring step along SSCM is of vital importance to deal with problems, to react flexible on market changes or to improve strategic as well as operational performance. Therefore, the SC monitoring step can lead to changes within the normative step (re-definition of the SC), network design (re-design), planning (re-planning), and execution.

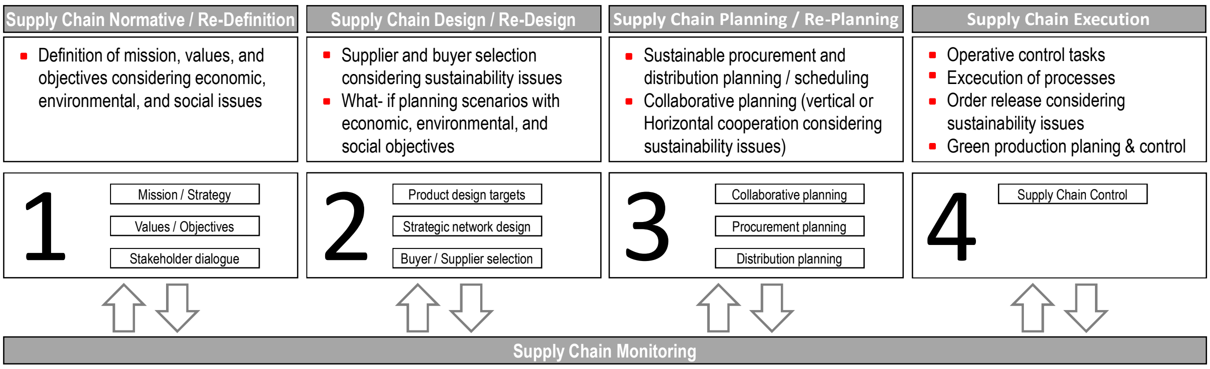


Figure 1: Framework of SSCM

4 STAKEHOLDER INTEGRATION

Stakeholders are so far hardly considered within supply chain management. This paper presents a 4-step-approach to integrate sustainability into supply chain management using fuzzy logic and taking stakeholder requirements into account. Fuzzy logic is applied as information is sometimes imprecise, uncertain, and hard to quantify. Actually, many companies have difficulties in obtaining information about stakeholders and their requirements. Considering stakeholder related issues such as stakeholder relevance or the importance of stakeholder requirements demand linguistic variables. Therefore, this approach incorporates fuzzy logic to transfer natural language into computable figures.
In the 1st step relevant stakeholders are defined. The 2nd step determines and prioritises stakeholder requirements in terms of sustainability. The definition of measures to satisfy stakeholder requirements constitutes step 3. Finally, step 4 assesses the identified measures. In the following this approach will be introduced in detail.

<u>Step 1: Identify stakeholders:</u> Each company has to identify its stakeholders and their relevance. Mitchell et al. suggest three criteria – power, legitimacy, and urgency - to identify stakeholders [11]:

- power: ability to let somebody do something which he would not have done otherwise,
- legitimacy: state of having proper and appropriate assumptions according to norms and values, and
- urgency: time-sensibility and criticality of stakeholder requirements.

Stakeholder groups with power as well as legitimate and urgent requirements can be denoted as relevant stakeholders. Stakeholder groups with low power, legitimate or urgent requirements can be denoted as less relevant stakeholders. Power, legitimacy, and urgency are defined as (linguistic) variables whose values are words in natural language. Values such as "very low", "low" are called linguistic terms. For each linguistic term a trapezoidal membership function is used:

$$\mu(x) = (a;\ b;\ c;\ d) = \begin{cases} 0 & \text{for } x < a \\ \dfrac{x-a}{b-a} & \text{for } a \le x < b \\ 1 & \text{for } b \le x < c \\ \dfrac{x-d}{c-d} & \text{for } c \le x < d \\ 0 & \text{for } d < x \end{cases}$$

Figure 2 shows linguistic terms and fuzzy membership functions μ(x) = (a;b;c;d) used in this approach to characterize power, legitimacy, and urgency (linguistic variables).

Linguistic terms	Membership function (a;b;c;d)
Very low	(0;0;0,1;0,3)
Low	(0,1;0,3;0,3;0,5)
Medium	(0,3;0,5;0,5;0,7)
High	(0,5;0,7;0,7;0,9)
Very high	(0,7;0,9;1;1)

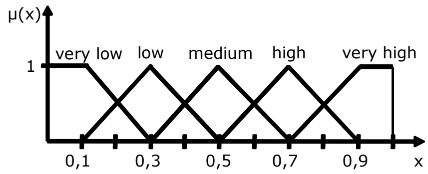


Figure 2: Linguistic terms and membership functions (power, legitimacy, and urgency)

Very often decisions are made in groups of decision makers. Therefore, the membership functions for every criterion have to be aggregated using, for instance, the approach by Chen et al. [12]. According to Chen et al., the trapezoidal overall membership function of different decision makers k (k=1,…,K) is μ(x) = (a;b;c;d), where:

$$a = \min\{a_k\},\quad b = \frac{1}{K}\cdot\sum_{k=1}^{K} b_k,\quad c = \frac{1}{K}\cdot\sum_{k=1}^{K} c_k,\quad d = \max\{d_k\}.$$

To ascertain the stakeholder relevance the overall membership functions of all criteria are multiplied:

$$\mu_{relevance} = \mu_p \cdot \mu_l \cdot \mu_u \approx (a_p \cdot a_l \cdot a_u; b_p \cdot b_l \cdot b_u; c_p \cdot c_l \cdot c_u; d_p \cdot d_l \cdot d_u)$$

μ_p, μ_l, and μ_u denote the overall membership functions of a stakeholder in terms of power, legitimacy, and urgency. This has to be done for each stakeholder.

Step 2: Determining / prioritising stakeholder requirements: In the second step the company has to determine major requirements of each stakeholder using primary and secondary analysis (surveys, complaints analysis, field surveys, literature surveys [2], and expert panels). After that, each stakeholder is asked to assess the requirements of that stakeholder group, if possible, otherwise all requirements should be treated equally. Each stakeholder expresses the importance of its requirements in linguistic terms, such as: "very important", "important", "moderately important", and "less important". Figure 3 shows linguistic terms and fuzzy membership functions μ(x) = (a;b;c;d) used to characterise the importance of each requirement within a stakeholder group.

Afterwards, the stakeholder relevance membership function and the membership function for each stakeholder requirement are multiplied to determine the importance of a requirement to the company. As certain requirements may double, doubling requirements are summed up after multiplication. By means of this approach the company has a list of sustainability-related requirements which are weighted and thus the relative importance of requirements is known. Within this procedure, it is necessary to work with disjoint stakeholder requirements, i.e. the fulfilment of one stakeholder requirements does not automatically lead to the fulfilment of another one. Therefore in preparation for step 2, all requirements should be broken down to disjoint requirements.

Linguistic terms	Membership function (a;b;c;d)
Less important	(0;0;2;4)
Moderately important	(2;4;4;6)
Important	(4;6;6;8)
Very important	(6;8;10;10)

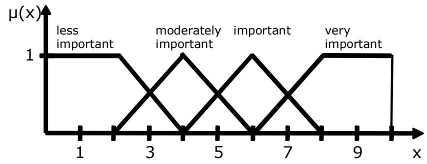


Figure 3: Linguistic terms and membership functions (importance of requirement)

Step 3: Defining measures to satisfy requirements: Knowing stakeholder requirements companies should deduce sustainability measures within the different steps of SCM presented in section 3. Each sustainability measure contributes differently to satisfy stakeholder requirements. For example, the certification according to ISO 14001 as a sustainability measure may contribute to customer requirements very much, however, due to its low legitimacy this measure may have low influence on stakeholders like non-governmental organizations [1]. Therefore, decision makers have to decide to which amount each sustainability measure contributes to stakeholder requirements. To express the contribution of each sustainability measures to the fulfilment of stakeholder requirements linguistic terms such as "very low or no", "low", "medium", "high", and "very high" can be used. A negative correlation between sustainability measure and stakeholder requirement is interpreted as "none" contribution. Figure 4 shows linguistic terms and fuzzy membership functions μ(x) = (a;b;c;d) used to characterize the contribution of measures to the fulfilment of stakeholder requirements. The individual perceptions of all decision makers have to be aggregate according to procedure described in step 1.

Linguistic terms	Membership function (a;b;c;d)
Very low or none	(0;0;0,1;0,3)
Low	(0,1;0,3;0,3;0,5)
Medium	(0,3;0,5;0,5;0,7)
High	(0,5;0,7;0,7;0,9)
Very high	(0,7;0,9;1;1)

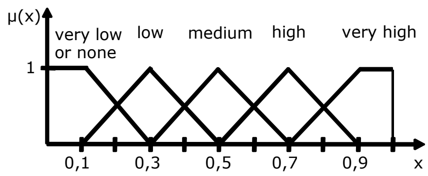


Figure 4: Linguistic terms and membership functions (contribution to stakeholder requirements)

Step 4: Assessing measures: The last step of this approach assesses the identified sustainability measures in terms of stakeholder relevance, stakeholder requirements as well as the contribution of the defined measures to satisfy stakeholder requirements. Based on this information, it is possible to calculate the importance of each measure to satisfy overall stakeholder requirements and to identify the most important sustainability measures. In step 2 the importance of a requirement to the company was determined considering stakeholder relevance. Now the membership function of the importance of a requirement and the membership function of the contribution of sustainability measures to stakeholder requirements have to be multiplied. Afterwards these products are summed up for each requirement. This leads to fuzzy numbers that characterise the importance of each sustainability measure. The fuzzy numbers have to be transferred into real numbers to compare the sustainability measures. The center of area method can be exploited as a defuzzification approach. For each sustainability measure the 4 numbers a, b, c, and d are summed up and divided by 4. The received crisp numbers can be compared and ranked. The sustainability measure with the highest crisp number fulfils stakeholder requirments best.

5 AN ILLUSTRATIVE EXAMPLE

The following hypothetical example illustrates the presented approach. A company considers two stakeholders S1 and S2. There are two decision makers in the company. They assess the criteria in step 1 as shown in Table 1. Afterwards, the results of both decision makers are aggregated. Table 2 shows the results. To ascertain the overall stakeholder relevance the overall membership functions of all criteria are multiplied, Table 3.

Stakeholder	Decision maker 1			Decision maker 2		
	Power	Legitimacy	Urgency	Power	Legitimacy	Urgency
S1	high (0,5;0,7;0,7;0,9)	medium (0,3;0,5;0,5;0,7)	low (0,1;0,3;0,3;0,5)	very high (0,7;0,9;1;1)	low (0,1;0,3;0,3;0,5)	very low (0;0;0,1;0,3)
S2	high (0,5;0,7;0,7;0,9)	low (0,1;0,3;0,3;0,5)	medium (0,3;0,5;0,5;0,7)	medium (0,3;0,5;0,5;0,7)	medium (0,3;0,5;0,5;0,7)	high (0,5;0,7;0,7;0,9)

Table 1: Stakeholder assessment (multiple decision makers)

Stakeholder	Decision maker 1 and 2		
	Power	Legitimacy	Urgency
S1	(0,5;0,8;0,85;1)	(0,1;0,4;0,4;0,7)	(0;0,15;0,2;0,5)
S2	(0,3;0,6;0,6;0,9)	(0,1;0,4;0,4;0,7)	(0,3;0,6;0,6;0,9)

Table 2: Overall stakeholder assessment

Stakeholder	Overall stakeholder relevance
S1	(0;0,048;0,068;0,35)
S2	(0,009;0,144;0,144;0,567)

Table 3: Overall stakeholder relevance

In step 2, each stakeholder is asked about his requirements (R1, R2, R3, and R4) and how each stakeholder assesses the importance of these requirements, Table 4. It is assumed that all stakeholder requirements are disjoint. Afterwards, the overall stakeholder relevance membership functions and the membership function for each stakeholder requirement are multiplied to determine the importance of a requirement to the company, Table 5.

Stakeholder	Requirements	Preference
S1	R1	Moderately important (2;4;4;6)
	R2	Very important (6;8;10;10)
S2	R3	Important (4;6;6;8)
	R4	Very important (6;8;10;10)

Table 4: Relative weighting of requirements by stakeholders

Stakeholder	Stakeholder relevance	Requir e-ments	Preferences for requirements	Weighted importance of requirements
S1	(0;0,048;0,068;0,35)	R1	(2;4;4;6)	(0;0,192;0,272;2,1)
		R2	(6;8;10;10)	(0;0,384;0,68;3,5)
S2	(0,009;0,144;0,144;0,567)	R3	(4;6;6;8)	(0,036;0,864;0,864;4,536)
		R4	(6;8;10;10)	(0,054;1,152;1,44;5,67)

Table 5: Weighted importance of stakeholder requirements

In step 3, the company identifies alternative sustainability measures for SSCM. They are denoted with SM1, SM2, and SM3 in Table 6. Each decision maker assesses the contribution of the identified measures to the fulfilment of stakeholder requirements using linguistic terms from Figure 4. Afterwards, the results of both decision makers are aggregated, Table 7.

Requirement and its importance		Decision maker 1		
		SM1	**SM2**	**SM3**
R1	(0;0,192;0,272;2,1)	high (0,5;0,7;0,7;0,9)	low (0,1;0,3;0,3;0,5)	high (0,5;0,7;0,7;0,9)
R2	(0;0,384;0,68;3,5)	medium (0,3;0,5;0,5;0,7)	medium (0,3;0,5;0,5;0,7)	high (0,5;0,7;0,7;0,9)
R3	(0,036;0,864;0,864;4,536)	very high (0,7;0,9;1;1)	very high (0,7;0,9;1;1)	none (0;0;0,1;0,3)
R4	(0,054;1,152;1,44;5,67)	none (0;0;0,1;0,3)	medium (0,3;0,5;0,5;0,7)	none (0;0;0,1;0,3)
		Decision maker 2		
		SM1	**SM2**	**SM3**
R1	(0;0,192;0,272;2,1)	high (0,5;0,7;0,7;0,9)	none (0;0;0,1;0,3)	high (0,5;0,7;0,7;0,9)
R2	(0;0,384;0,68;3,5)	medium (0,3;0,5;0,5;0,7)	medium (0,3;0,5;0,5;0,7)	very high (0,7;0,9;1;1)
R3	(0,036;0,864;0,864;4,536)	high (0,5;0,7;0,7;0,9)	high (0,5;0,7;0,7;0,9)	low (0,1;0,3;0,3;0,5)
R4	(0,054;1,152;1,44;5,67)	low (0,1;0,3;0,3;0,5)	medium (0,3;0,5;0,5;0,7)	none (0;0;0,1;0,3)

Table 6: Contribution of sustainability measures to stakeholder requirements (multiple decision makers)

Requirement and its importance		SM1	SM2	SM3
R1	(0;0,192;0,272;2,1)	(0,5;0,7;0,7;0,9)	(0;0,15;0,65;0,5)	(0,5;0,7;0,7;0,9)
R2	(0;0,384;0,68;3,5)	(0,3;0,5;0,5;0,7)	(0,3;0,5;0,5;0,7)	(0,5;0,8;0,85;1)
R3	(0,036;0,864;0,864;4,536)	(0,5;0,8;0,85;1)	(0,5;0,8;0,85;1)	(0;0,15;0,2;0,5)
R4	(0,054;1,152;1,44;5,67)	(0;0,15;0,2;0,5)	(0,3;0,5;0,5;0,7)	(0;0;0,1;0,3)

Table 7: Contribution of sustainability measures to stakeholder requirements

In step 4, the membership function of stakeholder relevance and membership function for the contribution of sustainability measures to stakeholder requirements are multiplied and summed up for each sustainability measure, defuzzyfied, and ranked, Table 8. In this example sustainability measure SM2 is the most important one, as it satisfies key stakeholders and is secondly most efficient due to its high contribution to stakeholder requirements.

	SM1	SM2	SM3
R1	(0;0,1344;0,1904;1,89)	(0;0,0288;0,1768;1,05)	(0;0,1344;0,1904;1,89)
R2	(0;0,192;0,34;2,45)	(0;0,192;0,34;2,45)	(0;0,3072;0,578;3,5)
R3	(0,018;0,6912;0,7344;4,536)	(0,018;0,6912;0,7344;4,536)	(0;0,1296;0,1728;2,268)
R4	(0;0,1728;0,288;2,835)	(0,0162;0,576;0,72;3,969)	(0;0;0,144;1,701)
Aggregation Σ	(0,018;1,1904;1,5528;11,711)	(0,0342;1,488;1,9712;12,005)	(0;0,5712;1,0852;9,359)
Defuzzification	3,61805	3,8746	2,75385
Ranking	2	1	3

Table 8: Final decision making

6 SUMMARY AND CONCLUSION

In literature many sustainability measures are discussed, but so far no appropriate decision support approach was available that facilitates decisions on sustainability measures regarding stakeholder relevance. A holistic framework for SSCM was proposed considering SC strategy definition, re-definition, (re-)design, (re-)planning, and execution. Furthermore, a fuzzy-based approach to tackle some degree of subjectivity within decision making in sustainable supply chain context was presented. The approach supports groups of decision makers as well as single decision makers to integrate sustainability into supply chain management using fuzzy logic.

The paper presents a 4-step-approach: identify stakeholders, determine and prioritise stakeholder requirements, define measures to satisfy stakeholder requirements, and finally assessing sustainability measures.

This approach will qualify companies to select sustainability measures to handle rising complexity within sustainable supply chain decision making context.

7 REFERENCES

- [1] Mueller, M.; dos Santos, V. G.; Seuring, S. (2009): The contribution of environmental and social standards towards ensuring legitimacy in supply chain governance. In: Journal of Business Ethics, 89:509-523.
- [2] Vojdani, N.; Knop, M. (2010): Integrating sustainability into supply chain management – a stakeholder perspective. In: Sihn, W. (ed.); Kuhlang, P. (ed.): Sustainable Production and Logistics in Global Networks – Proceedings of 43rd CIRP International Conference on Manufacturing Systems, Vienna, May 26-28, pp. 195-203.
- [3] Carter, C. R.; Roger, D. S. (2008): A framework of sustainable supply chain management: moving toward new theory. In: International Journal of Physical Distribution & Logistics Management, 38:360-387.
- [4] Gold, S.; Seuring, S.; Beske, P. (2010): Sustainable supply chain management and inter-organizational resources: a literature review. In: Corporate Social Responsibility and Environmental Management, 17:230-245.
- [5] Freeman, R. E.: Strategic management (1984): a stakeholder approach. Pitman, Boston.

- [6] Welford, R.; Chan, C.; Man, M. (2007): Priorities for corporate social responsibility: a survey of business and their stakeholders. In: Corporate Social Responsibility and Environmental Management, 15:52-62.
- [7] Herman, S. (2005): Corporate Sustainability Branding – Nachhaltigkeits- und stakeholderorientierte Profilierung von Unternehmensmarken. Wiesbaden: Deutscher Universitäts-Verlag.
- [8] Schaltegger, S.; Harms, D. (2010): Sustainable Supply Chain Management. Praxisstand in deutschen Unternehmen, Lüneburg.
- [9] van Huijstee, M.; Glasberger, P. (2008): The practice of stakeholder dialogue between multinationals and NGOs. In: Corporate Social Responsibility and Environmental Management, 15:298-310.
- [10] Kotzab, H.; Schütz, S. (2009): Nachhaltiges Supply Chain Management in der Konsumgüterwirtschaft – Erfahrungen von Nestlé, Sustainable Logistics, Magdeburg, 57-72.
- [11] Mitchell, R. K., Agle, B. R., Wood, D. J. (1997): Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. In: Academy of Management Review, 22:853-886.
- [12] Chen, C.-T.; Lin, C.-T.; Huang, S.-F. (2006): A fuzzy approach for supplier evaluation and selection in supply chain management. In: International Journal of Production Economics, 2:289-301.

CUSTOMER AND SUPPLIER COLLABORATION DURING PRODUCT SPECIFICATION - PROBLEMS OF INFORMATION GATHERING AND SHARING

Stefan Wiesner[1], Falk Steinberg[2], Marcus Seifert[3]

[1], [3] Bremer Institut für Produktion und Logistik GmbH,
Hochschulring 20, 28359 Bremen, Germany; {wie, sf}@biba.uni-bremen.de

[2] Brandenburgische Technische Universität Cottbus, Lehrstuhl Qualitätsmanagement,
Siemens-Halske Ring 14, 03046 Cottbus, Germany; falk.steinberg@tu-cottbus.de

ABSTRACT

The increasing demand for individually customized products is affecting the structure and processes of the involved supply chains. Growing complexity of the products has led to the transformation of linear supply chains to Collaborative Networks (CN) of enterprises, which are dynamically established for specific business opportunities. Especially Small and Medium-sized Enterprises (SME) are affected, as they are required to transform from suppliers of standardised parts to problem solvers, but often they are not able to offer the required competencies to develop and manufacture such products by themselves.
This has led to the necessity to involve the suppliers of product contributions inside the CN directly into the development and manufacturing process as well. Stronger collaboration in the CN is already necessary in an early phase. E.g., when bidding for a contract, the technical product specification has to be defined already. From a logistics point of view, this includes information and material logistics as well. Decisions made in this early phase have a great influence on the quality of the final product and its success. Out of the Quality Management (QM) perspective, the requirements of different stakeholders to the product, the customer being the most important, have to be matched as close as possible. But those requirements may not be clear from the beginning or are subject to unforeseen changes. The success of CN offers for individualised products is therefore dependent on the ability to collaboratively identify and match complex and volatile customer requirements, which have direct and dynamic influence on the necessary logistic configuration. There exists a need for direct customer and supplier involvement into product specification.

In this paper, problems of information gathering and sharing in the context of customer and supplier involvement in product specification are identified. Especially the challenge of Requirements Engineering (RE) and its implementation in a collaborative environment is considered. The gathering of all requirements for the offering of a high-quality solution is often hindered by the fact that not all information needs of the network partners are known during requirements take up. Furthermore, there is a frequent lack of standardisation or IT support to communicate relevant information to the appropriate network partner at the right time. This leads to time-consuming inquiries or wrong product specifications. On the basis of the findings, requirements to support collaborative RE for product specification in CN are identified.

INTRODUCTION

While technological competence has been sufficient in the past to create successful products, nowadays even Small and Medium-sized Enterprise (SME) are required to become "problem-solvers" for the customer. However, they often do not possess the required competencies to develop and manufacture innovative solutions by themselves [Schiemann 2008]. Instead of being created in a linear supply chain, the individual solutions are often realised in the structure of a project, based on the customer's requirements [Brauweiler 2008], [Svensson 2002]. Therefore, a Collaborative Network (CN) of enterprises is formed dynamically for the specific business opportunity (see Figure 3). In this network, the core competencies of the single partners are combined to provide the joint capabilities needed to specify and realize the final product. The collaboration is supposed to facilitate mutual benefits, measured in gains of time, quality and cost.

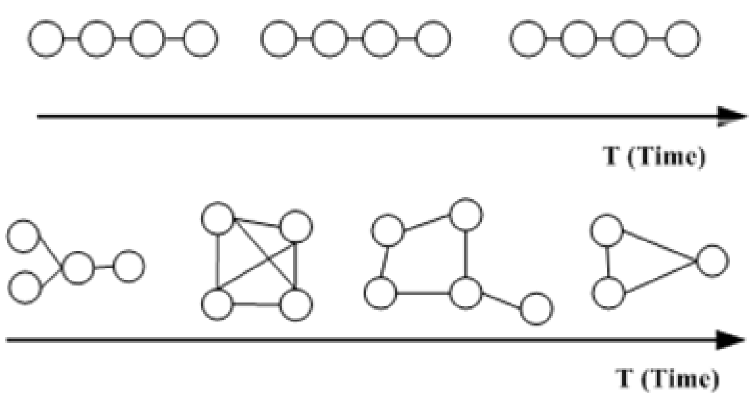


Figure 3: Supply Chains (above) vs. dynamic Collaborative Networks (CN, below)

Product specification for customer individual solutions may become very extensive and time-consuming due to the complexity of the products and the required flexibility in design. The customer is expecting detailed information about the technical solution, the price and the delivery time. Satisfaction of the customer is only possible, if all of his requirements towards the product are fulfilled. Requirements hereby comprise the needs of the user of the solution and his environment [Cheng & Atlee 2007]. Additional requirements for the product may come from other stakeholders, such as suppliers or even competitors. The degree to which the requirements are realised in the solution is called product quality [Linß 2005]. In order to achieve a sufficient product quality, process quality is a basic prerequisite [Epple 2000]. By appropriately executing the processes in the Collaborative Network, customer requirements are fulfilled and product quality is ensured [Pfeifer, Schmitt 2007].
In order to specify a successful high quality product in a CN, it is therefore necessary to implement a suitable Requirements Engineering (RE) approach. RE describes the process towards creating a functional specification which enables the realisation of the technical solution by elicitation, modelling, analysis, validation and management of requirements [Cheng & Atlee 2007]:

1. Thorough understanding of the needs of users, customers and other stakeholders as a basis for product quality and
2. ensure process quality by communication of all relevant information to the concerned network partners at the right time, in the right way.

Success of a Collaborative Network is therefore not anymore only based on the existing technological competence of its partners, but on a suitable approach for Requirements Engineering and Information Logistics already during the early phase of product specification. The network should be able to elaborate the customer's wishes, even if they are not explicitly expressed. The earlier the requirements are clarified, the faster and more cost effective product specification can be accomplished [Schienmann 2002]. As can be seen in Figure 4, the degree of freedom for design decisions is relatively high in the early phases of product conception, while it drops rapidly to almost zero when the product is manufactured. On the other hand, the cost for the implementation of a changing requirement is fairly low before product development starts. Because of that it is important, that the requirements are: *correct*, *complete, consistent, unambiguous*, *realizable and verifiable* the first time they are taken up to avoid costly reworks in a later phase.

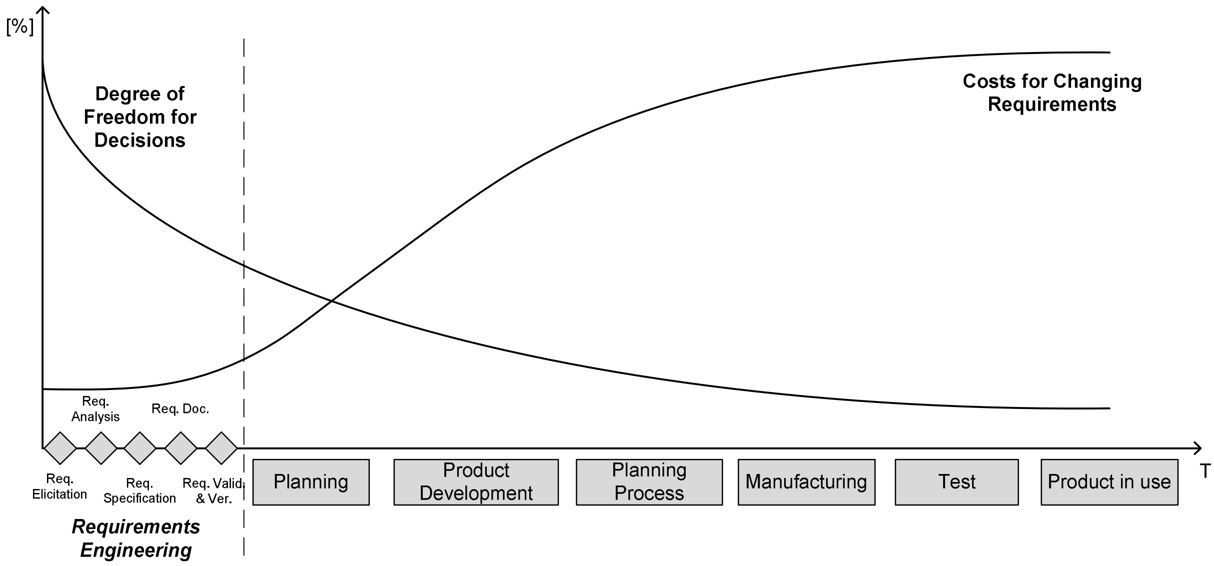


Figure 4: Costs for changing requirements [Woll 1996]

For the specification of customer individual products, involvement of all partners of the Collaborative Network is generally necessary. Requirements towards the solution have to be determined together with the customer and distributed among the involved network partners. For this process, it has to be clarified which partner needs what kind of information at any given time and how communication interfaces have to be designed. If this is not the case, the solution might not comply with the given requirements in spite of existing technological competence in the CN. In fact, the resulting product would be of low quality and success of the Collaborative Network in the market would be endangered.

PROBLEM ANALYSIS

As shown in the previous section, customer requirements are the basis for the development of an individual technical solution and their comprehensive take up is key to a high quality product. As the decisions made during Requirements Engineering directly influence the quality of the final product, they have to be based on complete and reliable data. The requirements, which even may still change during engineering, have to be matched as close and as early as possible. The transformation from supply chains combining standardised parts to Collaborative Networks working as problem solvers leads to an increasing complexity in product specification. An accurate functional specification of the solution needs detailed information about stakeholder requirements [Baumgarten 2008]. Therefore, individualisation of the products has led to the need of direct customer and supplier involvement into product specification [Seifert 2009]. Success of Collaborative Networks depends on the ability to include these stakeholders into Requirements Engineering.

Established validation concepts for requirements, like development and quality assessments, are normally applied to prototypes. Generally this is not possible for unique customer individual products [Sondermann 2007]. Because of that, it is important to make validation of requirements possible prior to manufacturing. This is already a complex task for a single enterprise and becomes even more difficult in a CN. The determination of all required information to develop a high quality solution is e.g. limited by the knowledge of the information needs of the network partners. If this knowledge is incomplete, severe problems are likely to arise which are subsequently documented from a case study. The case represents a CN for individual plastic injection moulding machines, characterized by the close participation of the customer and suppliers in product specification. The following problem areas could be identified:

- **Imperfect elicitation of customer requirements**
  The information needs of all supply chain partners are often not completely known to the customer contact point [Nohr, Roos 2004]. Requirements elicitation is conducted by independent sales representatives for the case study. Mostly only cornerstones of the project (products, costs) are discussed, while technical details

are omitted. On the one hand, this can lead to unrealistic expectancies at the side of the customer and on the other hand important information, e.g. for the suppliers, is not taken up as they do not participate in requirements elicitation.

- **Insufficient communication of customer requirements**
  Due to non-standardised communication interfaces, the forwarding of customer requirements to the involved CN partners can be problematic. Suppliers enquire for missing information through the OEM, which in return contacts the sales representatives. Information is communicated at the wrong time, in the wrong way or even not at all. Missing documentation leads to time-consuming iterations or false requirements. Additional time is lost over communication channels due to different time-zones and unknown contact persons.
- **Difficult implementation of change requests**
  Changing conditions or technical updates may lead to concretisation or change requests by the customer. Inadequate communication and non standardised feedback leads to delays and misunderstandings. Dependencies between the requirements and the CN partners make the implementation of these requests a complex task, with a high frequency of rework.

The mentioned drawbacks in Information Logistics reduce the competitiveness of the case CN. Main challenges are:

- Problems in communication and coordination,
- Redundant work,
- Undesirable developments,
- Frequent inquiries,
- Intransparency of processes etc.

To meet the above challenges, it is crucial to analyse the current approaches in Quality Management and Requirements Engineering for CN in particular. On the one hand, the complete take up of all requirements needed to specify all product contributions by the network partners has to be ensured. On the other hand, the communication of this information to the right partner, at the right time and in the right way has to be guaranteed. In this case, approaches of Information Logistics management can be used. Subject of Information Logistics is to provide the comprehensive and coordinated planning of information systems within and between companies [Arnold et al.].

STATE-OF-THE-ART

A customer individual solution is a complex product and it is absolutely necessary to take up the customer requirements completely. This means that the underlying problem has to be interpreted correctly in the sense of the customer and that it has to be translated into the correct product requirements. As described earlier, it is a prerequisite to ensure product and process quality in the sense of Quality Management. All information necessary for the development of the solution has to be taken up completely and made accessible [VDI 1983]. This procedure helps to minimize inquiries, wrong developments and redundancies, which lead to losses in time and capacity [Eversheim 1998]. A potential customer expects accurate information about the technical solution, the price and delivery time. Therefore, a structured approach for Requirements Engineering for customer individual products has to be adopted. For Collaborative Networks to stay competitive, efficient collaboration in RE is necessary. A complete take up of customer requirements will improve the quality of the final product. New methods for RE in CN are needed, based on the state-of-the-art described below. The main tasks of Requirements Engineering can be structured as follows [Jesse 2008], [Cheng & Atlee 2007]:

- **Requirements Elicitation**
  During Requirements Determination, the wishes, suggestions and conceptions of the customer towards a solution are taken up. Additionally, the goals and motives for the product specification are defined. Requirements can range from modifications of existing products to relatively unconstrained innovative requirements. Most of the elicitation techniques focus on the precision and variety of requirements details:

- *Stakeholder Identification* ensures that everyone affect by the new product is involved in elicitation of requirements.
- *Contextual techniques* analyse the environment of the product to guarantee that it is fit for use in this context.
- *Inventing Requirements* through brainstorming or workshops is used to find "buzz requirements" to make the product more appealing.
- *Feedback* through models or simulation allow for early assessment of the proposed solution.

In Collaborative Networks, Requirements Elicitation is often performed by autonomous sales agents. The agent sells on commission and advises the customers on the basis of the existing product portfolio. Specification of an individual technical solution requires especially product and performance related data. These are generally communicated from the customer to the agent in an unstructured way. Checklists can be used to structure the information. However, the lists have to be prepared individually for each product and provide pre-defined answers and solutions [Krömker 2000]. Existing tools for this phase include affinity diagrams, hierarchy diagrams etc. All those tools are dependent on the knowledge of information needs of the CN partners. The results of Requirements Determination can be e.g. used as input for House of Quality.

- **Requirements Analysis**
  The Requirements Analysis is used for processing and examining the elicitated requirements. They are structured formally and a consensus on their understanding is reached [Schienmann 2002]. The requirements are analysed for errors, like ambiguities, inconsistencies, or incompleteness. Additionally, anomalies like unknown interactions between requirements, obstacles to satisfaction or missing assumptions are identified. Risk or impact analysis help to better understand the requirements and interrelationships for decision support. A systematic approach is supported by methods like FMECA (Failure Mode, Effects and Criticality Analysis), OFD etc [Hohler 2007].
- **Requirements Specification and Documentation**
  Agreement and decision on which requirements are relevant for product specification are subject of Requirements Specification [Geisser et al. 2007]. Development of a technical solution for a customer individual problem is a complex task. Performing the specification needs comprehensive knowledge of customer requirements by all involved members of the CN. Each partner has to ensure the stipulated quality level. A close collaboration between the provider and the customer of the product is necessary in this phase. The decisions have to be available to all partners in the network. During Requirements Documentation the results of the specification are formalised and the technical specification is drafted.
- **Requirements Validation and Verification**
  In this phase, the requirements are validated and verified for quality of content and form [Schienmann 2002]. It is ensured, that the documentation accurately expresses the stakeholders needs. Therefore, validation usually requires the stakeholder to be directly involved into in reviewing the requirements. Conversely, verification checks if the formal description of requirements can be fulfilled by the envisioned product. Thus, the technical specification can be finalized with all requirements.

Collaboration in Requirements Engineering

In the case of distributed development, like the product specification in Collaborative Networks, communication plays a key role [Geisser et al. 2007]. All stakeholders relevant for project success (from the customer to the supplying CN partners) should participate in Requirements Engineering [Schienmann 2002]. In practice however, due to time constraints this is often not the case. [Versteegen 2004]. Central problem is the high effort for information exchange between the partners. Requirements Management provides a framework for structuring and communicating requirements between CN partners [Schmitt & Kukolja 2007]. Its implementation should ensure comprehensiveness, uniqueness, traceability, consistency, completeness and testability of the elicitated requirements. However, independent organisational structures prevent standardised communication interfaces leading to information gaps. Information is exchanged on different channels (phone, fax, email etc.) with a high number of inquiries and information loss. Also ICT-systems can be incompatible, allowing only for exchange of unstructured information. Audio, video or priorities for certain information is not used, as well as supervision of deadlines and inquiries. Therefore, the customer and suppliers are not well integrated in Requirements Engineering. Information requirements for the development of new parts, which are regularly needed for customer individual products, are not predictable.

As described above, various methods to support RE exist. However, they are mostly only focused on one phase of the RE and are not designed for a collaborative environment. Collaborative hereby meaning the integration of all stakeholders, distributed in organisation, time and space as well as their cooperation over all phases of RE [Hildenbrandt et al. 2007]. The described methods have in common, that collaboration of the customer and suppliers is only possible to a low degree. New RE methods are needed, which support the distributed elicitation, analysis and verification of requirements.

IMPLICATIONS FOR ICT SUPPORT OF REQUIREMENTS ENGINEERING

All information generated, from Requirements Elicitation to Requirements Validation and Verification, has to be available to all involved partners from the Collaborative Network to minimise redundancies, lack of transparency and incorrect decisions in product specification. A supporting information system would have to fulfil the following needs:

- Depending on information about requirements, the system should be able to identify the right partners for the respective requirements. In this case, it is a dynamic network. The Network should renew for each bid preparation according to product specifications.
- Furthermore all requirements are available to all network partners anytime to the full extent.
- All requirements are fully represented by pictures, text, audio and video. The understanding of the requirements is the same for all network partners, which will reduce misunderstandings.
- Through templates provided by the system, elicitation of requirements is simplified and standardised. This enhances transparency of Requirements Engineering for all partners of the network.
- The customer is included in the information system and has the possibilities to supervise the specifications of the product. If requirements are changing during the process of product specification, it's possible for the customer to put these new requirements into the system cloud directly.

Improved Information Logistics could be achieved through an *Information Cloud* (see Figure 5). The Information Cloud is representing a repository of all relevant information for product specification, which is accessible from various locations and provides additional services to the stakeholders (notification, filtering, templates etc.). Information between the cloud, the customer and the partners of the network could e.g. be exchanged via mobile phone apps. This increases the flexibility of the Collaborative Network, because it can be accessed from different points on the Information Cloud. The ability to upload, images or documents of assemblies or components in the information cloud reduces the risk of misunderstandings. Because of that, it is possible to reduce late changes in requirements to a minimum.

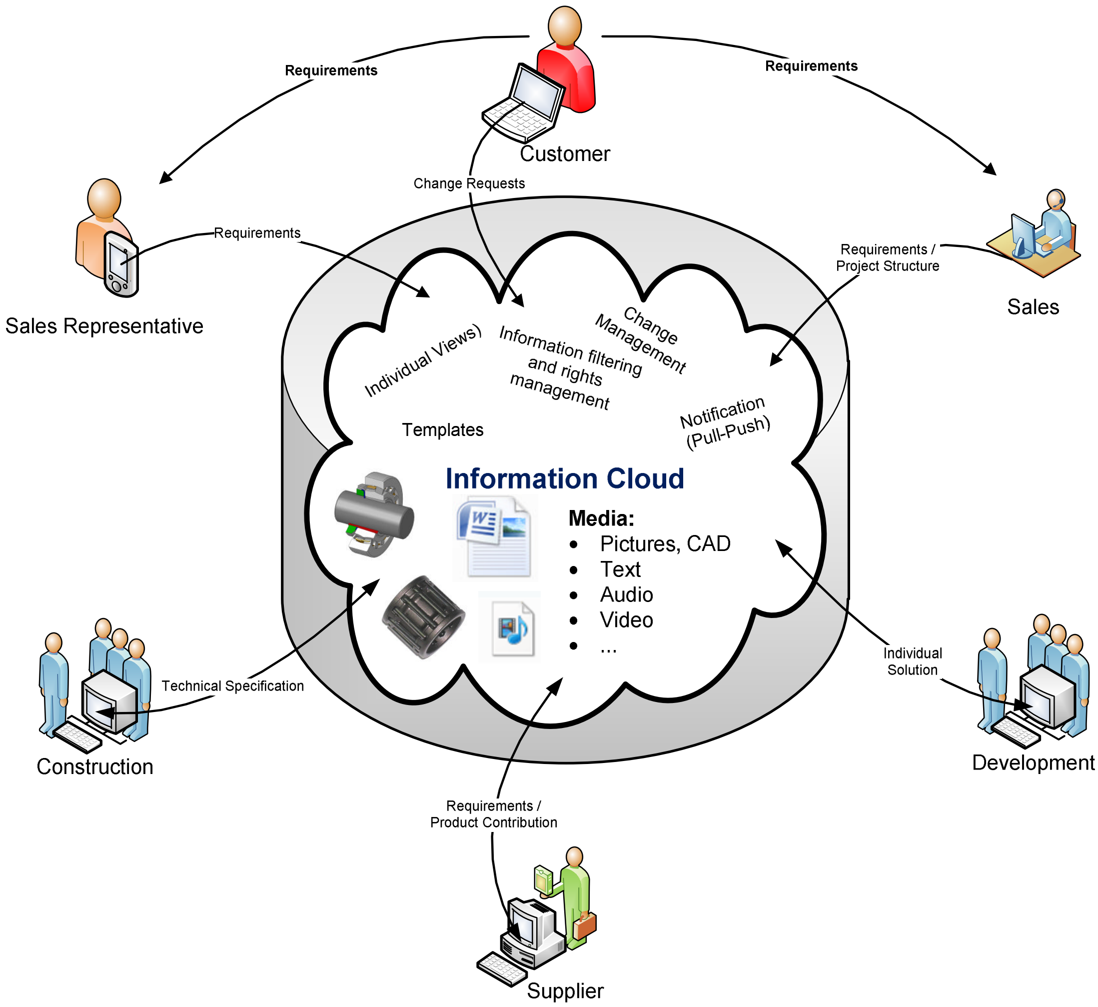


Figure 5: Supporting Customer and Supplier Collaboration during Product Specifications with the Information Cloud

CONCLUSIONS

Aim of improving product specification in Collaborative Networks is the rise of the success rate of the offered customer individual products. This includes time and resource advantages for product specification for all members of the network and for the customer. Changing requirements is always associated with high costs in the late stages of product development. Getting things right at the outset can save big amounts of effort that would have been necessary to put things right later [Hull et al. 2011]. The Collaborative Network should therefore not only determine requirements towards the final product. As stated before, product quality is directly related to process quality. Because of that, Requirements Engineering should also determine process requirements for the network. Only in this way it can be secured already during product specification, that the Collaborative Network has the required competencies to manufacture the product according to the customer requirements and provide a high-quality solution.

The proposed way to support product specification is Information Logistics support by the Information Cloud. This would allow the preparation of flexible and requirement-compatible specifications by Collaborative Networks, which therefore can place successful and competitive offers on the market. For the development and implementation of the Information Cloud for product specification in CN, further research is necessary. It has to be clarified, how to configure a CN for a specific business opportunity. The required contents and interfaces of the cloud have to be defined. Finally, collaboration tools have to be developed and provided, which address the issues in Information Logistics and Requirements Engineering mentioned in this paper.

REFERENCES:

Arnold, D.; Isermann, H.; Kuhn, A.; Furmans, K.; Tempelmeier, H. (2008): Handbuch Logistik (VDI-Buch). 3. Auflage. Springer Berlin.

Baumgarten, H. (2008): Das Beste der Logistik. Innovationen, Strategien, Umsetzungen. 1. Edition. Springer, Berlin.

Brauweiler, H.-C. (2008): Unternehmensführung heute. Oldenbourg, München.

Cheng, B.; Atlee, J. (2007): Research Directions in Requirements Engineering. In 2007 Future of Software Engineering (FOSE '07). IEEE Computer Society, Washington, DC, USA.

Epple, M. J. (2000): Prozessqualität – Ansätze zum Qualitätsmanagement bei innerbetrieblichen und zwischenbetrieblichen Prozessen. Difo, Bamberg.

Eversheim W. (1998): Organisation in der Produktionstechnik 2 – Konstruktion. Springer Verlag Berlin.

Geisser, M. et al. (2007): Verteiltes, internetbasiertes Requirements Engineering. In Wirtschaftsinformatik 49 (2007) 3, S. 199-207.

Hildenbrandt, T. et al. (2007): Ansätze zur kollaborativen Softwareerstellung. In Wirtschaftsinformatik 49 (2007) Sonderheft, S. 72-80.

Hohler, B. (2007): Qualitätsmanagement bei der Softwareentwicklung. In: Pfeifer, T.; Schmitt, R.; (2007): Masing – Handbuch Qualitätsmanagement. 5. Auflage. Hanser München, Wien. S. 817-845.

Hull, E.; Jackson, K.; Dick, J. (2011): Requirements Engineering. Third Edition. Springer London.

Jesse, S. (2008): Tutorium: Erhebung von Produktanforderungen durch den Requirements Engineer. In: Herzwurm, G.; Mikusz, M.: Industrialisierung des Software – Managements – Fachtagung des GI-Fachausschusses Management der Anwendungsentwicklung und –wartung im Fachbereich Wirtschaftsinformatik (WI-MAW). 1. Auflage. Bonn: Köllen Druck + Verlag GmbH. S. 195 – 204.

Krömker, M. (2000): Werkzeug zur durchgängigen Systemunterstützung der Angebotserstellung in der Unikat- und Kleinserienfertigung. Bremer Schriften zu Betriebstechnik und Arbeitswissenschaft 28, Mainz.

Linß, G. (2005): Qualitätsmanagement für Ingenieure. 2. Auflage. Hanser Verlag München, Wien

Pfeifer, T.; Schmitt, R.; (2007): Masing – Handbuch Qualitätsmanagement. 5. Auflage. Hanser München, Wien

Nohr, H.; Roos, A. W. (Eds.) (2004): Customer Knowledge Management: Erschließung und Anwendung von Kundenwissen. CKM-Berichte der Hochschule der Medien. 1. Edition. Logos, Berlin.

Schiemann, M. (2008): "Unternehmen nach Größenklassen – Überblick über KMU in der EU", Luxemburg 2008.

Schienmann, B. (2002): Kontinuierliches Anforderungsmanagement. Addison-Wesley, München.

Schmitt, R.; Kukolja, J. (2007): QCC: Quality Competence Center. FQS-DGQ-Band 86-06.

Seifert M. (2009): "Collaboration formation in virtual organisations by applying prospective performance measurement", dissertation, University of Bremen, Bremen.

Sondermann; J. P. (2007): Interne Qualitätsanforderungen und Anforderungsbewertung. In: Pfeifer, T.; Schmitt, R.; (2007): Masing – Handbuch Qualitätsmanagement. 5. Auflage. Hanser München, Wien. S. 387-404.

Svensson, C. (2002): Limits and opportunities in mass customization for "build to order" SMEs. In: Computers in industry, S. Vol. 49, No. 1 (2002), 77-89.

VDI (1983): Angebotserstellung in der Investitionsgüterindustrie. VDI-Verlag, Düsseldorf.

Versteegen, G. (2004): Anforderungsmanagement. Springer Verlag, Berlin.

Woll, R. (1996): Qualität erfordert Integration. In: Industrie-Management 12(4), S.65-68.

DEVELOPMENT OF A FRAMEWORK SUPPORTING ICT-BASED ENERGY EFFICIENT FREIGHT TRANSPORT

Jannicke Baalsrud Hauge[1], Hans Westerheim[2], Tor-Kjetil Moseng[2]

[1]Bremer Institut für Produktion und Logistik(BIBA), Hochschulring 20, 28359 Bremen;
baa@biba.uni-bremen.de
[2]Stiftelsen SINTEF, Postboks 4760 Sluppen, 7465 TRONDHEIM, Norway
Hans.Westerheim@sintef.no;TorKjetil.Moseng@sintef.no

ABSTRACT
During the next 20 years it is expected that the freight transport will increase with all its impact on the environment and on the life of citizen. CO_2 emissions as well as several other Green house gases, noise and dust from freight transport are already a problem today, and the EU is expecting that transport emissions will still increase. One third of these are estimated to be caused by freight [1].

Some evidences to this assumption are coming from the Commission's studies for 2020 forecasting a significant surge in transport flow unless trends change [2]:

- Internal transport within Western Europe is set to increase by 33%;
- Internal transport within Eastern Europe is expected to rise by 77%;
- Transport from eastern to Western Europe is set to grow by 68%;
- Transport from eastern to Western Europe is expected to increase by 55%.
-

Even though the emissions do have serious negative societal and ecological impacts, it is not possible to reduce the volume of transport to a very large extent. In a global world, freight transport has grown to be a complex system affected by several variables, so that it is not enough to trigger only one variable in order to reduce the negative effect. ICT has already been implemented as a supporting tool for increasing the energy-efficiency of freight transport, but the penetration of different solutions in the supply chain is not seamless and many stakeholders like small freight carriers do not profit from such systems up to now. Much effort has been put in the development of different ICT solutions intending to support energy efficiency, but most of them are not known to those who would take most advantage of them- the logistic service providers and freight carriers.

This paper will discuss the development of a framework aiming at giving a fast access to these results in order to use these for further developments or direct implementation in order to support the European Commission's strategy for increasing the sustainability of the European transport.

INTRODUCTION
"Transport is fundamental to our economy and society....Transport enables economic growth and job creation "[3,p.3] is stated in the new white paper on transport by the European Commission. In the same paper they state that congestion is of major concern, and thus actions need to be taken in order to reduce the negative impact. Additionally, from an economic point of view, the efficiency of logistic operations is crucial for the competitiveness of small and medium sized manufacturers and due to the globalisation of production, the transport volume increases. The European Commission has recently published a new analysis of the CO2 from the freight transport; the outcome is presented in the table below. This graphic, based on the TERM27 [4, 5] measures shows that the contribution to CO_2 emissions from transport/kilometre is slightly declining, and that the "The specific CO_2 emissions of the road sector were reduced between 1995 and 2008 by 13 % for freight transport. The reductions in road freight transport are due to both technical improvements and increased activity of the heavy-duty trucks".

Also the rail transport has become much more efficient, and can show a reduction of "13% in the same period, mostly as a result of both technological improvements and increased load factors" [6]. The logistic sector, esp. the freight transport, is not only vital for the competitiveness of the European industry, its contribution to the Co_2 and No_X emissions is, even though it declines per pkm, tremendous.

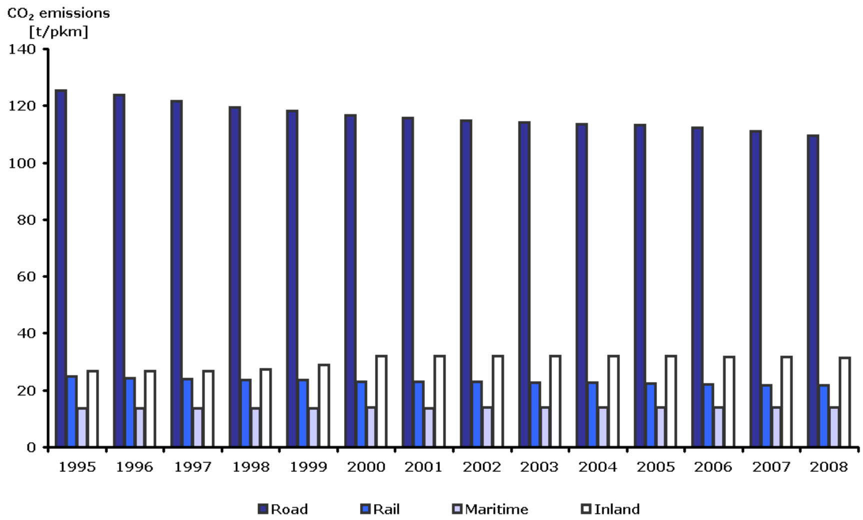


Figure 6: TERM27 Specific CO2 emissions per tonne-km and per mode of transport in Europe [5]

Consequently, a more efficient freight transport would contribute to the European industrial competitiveness as well as have a positive impact on the environment. The European Commission states in its white paper, that new technologies for vehicle and transport management as well the technological innovation are key enabler for lowering the emissions and increasing the sustainability [3,7,8].

The Commission concludes "EU research needs to address the full cycle of research, innovation and deployment in an integrated way through focusing on the most promising technologies and bringing together all actors involved"[3, p.13]. Consequently, "transport research and innovation policy should increasingly support in a coherent way the development and deployment of the key technologies needed to develop the EU transport system into a modern, efficient and user-friendly system. To be more effective, technological research needs to be complemented with a systems' approach, taking care of infrastructure and regulatory requirements, coordination of multiple actors and large demonstration projects to encourage market take-up."[3,p.13]. The success of this research policy is not solely dependent on how good EU manages to coordinate the research activities. It is much more dependent on the take-up and deployment rate within the target groups- freight carrier, logistic service providers and shippers.

Unless legal restrictions impose a specific standard, this rate will depend on the assessment of the expected benefits for the companies. Looking at the deployment rate of ICT solutions resulting out of research activities and exceeding the prototype and small scale industrial implementation level, it must be concluded that this rate is quite low, even though there are many research activities within efficient ICT based freight transport and mostly results are available for public access. A main reason may be the unstructured information about the solutions; how to implement them, which technologies they are based on as well as to what extent each of these contributes to the financial, societal and environmental sustainability. This information is however vital for any decision makers taking the decision on the necessary financial investment. Consequently, there is a need for a framework showing the link between the commercial and EU policies and how different information and communication technologies can contribute to these in different ways.

RESEARCH APPROACH

The European research landscape on transport shows large difference in their solution areas. It is expected that ICT will help to reduce the consumption of fossil fuel, thus reduce the transport cost. Seamless information flow and the increased use of intelligent cargo will also lead to a reduction of delays, making it easier to optimize the transport of goods in supply chains and to avoid accidents.

This can be realized by fully integrated multi-modal transport networks and will rely on the combination of advanced ICT solutions. Some of these are already available today, either as deployment projects, as prototypes out of research projects or for small scale industrial use. In some area, the research community have been able to develop new concepts like on intelligent cargo. There have also been much effort invested in the development of technologies supporting seamless information flow among partners (like projects looking at the interoperability, web-based solutions etc,) or using new technologies for tracking and tracing (GNSS and RFID). However, most research has been driven by an industrial need to optimise their processes in order to secure economical sustainability, and the positive aspects on societal and environmental sustainability were welcome side effects. This has lead to some imbalances in the research landscape. Dividing the research carried out on transport in four complementary areas shows this imbalance [9]:

1. Collaborative models for the logistic business
2. Transparent freight traffic control and enforcement
3. Shared technology infrastructures
4. Solutions for green and cost-effective freight transport

There are more solutions mainly contributing to the three first areas than to the last area, since such solutions have just recently started to be considered. In order to establish a framework which can improve the access to available and necessary information on the area of green and cost-effective freight transport, some criteria for assessment of the different solutions must first be established. Secondly, a taxonomy which makes it possible to describe and structure the information about e.g. the processes, roles, ICT etc. in a coherent way is requisitely. It is here important to look at how other existing solutions and frameworks are structured to gain some insights on how the taxonomy should be described. Finally, the information gathered and feedback from users will give indications on how to present the information to support the strategic goals of the commission and commercial stakeholders.

LOGISTICS FOR LIFE FRAMEWORK

Sustainability dimensions

Due to the increased awareness of the impact freight transport has on the environment several companies are assessed by their stakeholders according to their environmental and societal decisions [10]. The decision of investing in solutions environmental- and societal-friendly solutions will thus depend of the company's policy and which sustainability criteria being in focus in that policy. In general, the sustainability will have a financial, an environmental and a societal dimension. Assessing the impact of ICT is a challenge, since beneficial effects appear on various levels, i.e. direct effects, indirect effects and systemic effects.

For a long time, the financial dimension played the key role. In order to be able to fulfil the inherent goals of the European Commission regarding the long term sustainability of transport, this is not enough, and also the impact on other dimensions needs to be assessed. In consequence, there are several indicators that need to be considered [10]:

a. *Financial Sustainability (F) by, e.g.:*
    - F1: Reduction of transport costs
    - F2: Reduction of delays
    - F3: Efficiency of intermodal freight management

- F4: Improved balance of transport supply and demand.

b. *Environmental Sustainability (E) by, e.g.:*
   - E1: Reduction of CO_2 emissions
   - E2: Reduction of fossil fuel consumption
   - E3: Reduction of infrastructure environmental impact.

c. *Societal Sustainability (S) by, e.g.:*
   - S1: Reduction of transport accident fatalities
   - S2: Reduced congestion in urban areas
   - S3: Creating and safeguarding of jobs.
   - S4: More efficient access to transport services.
   - S5: More efficient infrastructure utilization.

In transportation, economic (financial), environmental and societal sustainability are strongly related and affecting one of them positively is highly likely to also affect one or two of the others.

Additionally to the challenges of assessing the impact from ICT on the different sustainability dimensions, the deployment of ICT in the transport sectors faces different barriers and the different users do have different requirements depending on company policy, size and needs.

Requirements on ICT solutions for freight efficiency

To which extent a prototype solution will be taken up after project's end depends on to what extent a solutions fulfils the strategic goal of a company. A requirement analysis carried out within the Logistics for Life project showed that most relevant functionalities for new ICT developments are (Rank 1 to 5; 1 least significant)[11]:

- Seamless information flow through the entire supply chain (38% ranked 5);
- Information on cargo status, e.g.: temperature, humidity control level (20% ranked 5 also same percentage ranked 4);
- Information on delays, rescheduling, traffic information, re-routing (26% ranked 5 and 23% ranked 4);
- Active fuel management. (26% ranked 4).

In the same survey, also the barriers to adoption of ICT for Energy Efficiency (Rank 1 to 5; 1 least significant) were collected, and this show the challenges our framework will need to deal with:

- Difficult to calculate the return on investment. (29% ranked 4)
- Cost of system integration. (29% ranked 4)
- Key customers and suppliers will not be interested paying more for the increased service (29% ranked 5).

The two first once should be delivered by sustainability assessment of the provided solutions. The third is more a matter of customer's priorities, but as a consequence of the increasing awareness of environmental impact of freight transport, more and more logistic service providers and freight carriers include green logistic as defined in [12] in their company strategies, since this is requested both from customer and authorities. At the moment there are only few possibilities to find already existing solutions being affordable for SMEs.

In a next step, it is necessary to identify existing frameworks in the transport sector that targets views suitable for the Logistics for LIFE framework. Using an already existing framework as a starting point will help to increase the deployment rate and also contribute to the establishment of a standard.

ARKTRANS model [13]

This section describes ARKTRANS - the Norwegian multimodal framework for ITS, which is used as starting point. ARKTRANS addresses multimodal transport and targets the transport sector in a generic and holistic way; the information is described in generic terms to be used across organisations and modes, while the information exchange is clearly defined between actors to enable interoperability within the sector. ARKTRANS is structured into different abstraction layers that describe different viewpoints, shown in Figure 7.

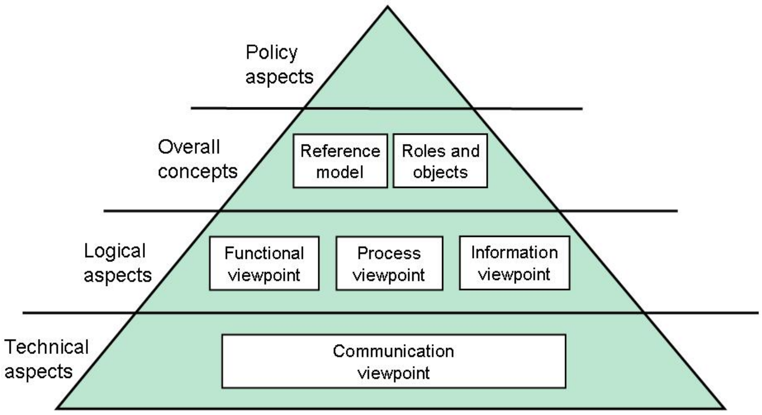


Figure 7: The ARKTRANS content

Figure 7 illustrates how the transport sector can be broken down into different abstraction layers:

- Overall concepts: includes a reference model that divides the transport sector into different domains, and role and object descriptions on stakeholders part of the sector.
- Logical aspects: describes necessary functions and interactions (i.e. processes) to be performed, and the information exchanged to accomplish these functions and interactions.
- Technical aspects: gives a brief overview of different technical standards within transport and ICT.

The functional viewpoint describes the functionalities necessary to complete a task within a process of tasks to fulfil a transport service. Each function is under the responsibility of a role (i.e. stakeholder) and as such related to one domain. It is not the intention to describe business internal processes, and therefore the information defined is the information that is required to exchange between the domains (and other important parts within the domains). The reference model is shown in figure 3:

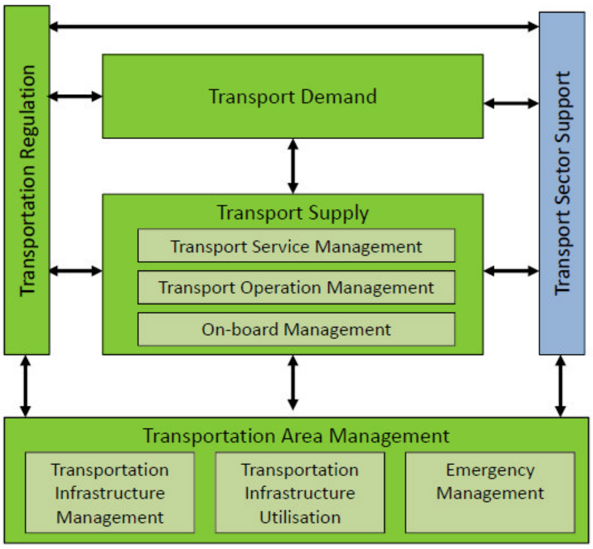


Figure 8: The ARKTRANS reference model version 7, functional view

The reference model contains the following domains:

- The Transport Demand domain: represents the transport user, which defines the transport demands, does transport planning, requests the required transport services, and follows up the transport.
- The Transport Supply domain: represents the transport supplier, i.e the one who offers the transport services. This domain is further divided into:
    - Transport Service Management: is responsible for providing transport services to the transport user in the Transport Demand domain. This also includes the management and execution of the transport operations (e.g. transport, passenger/goods handling, document handling, etc.).
    - Transport Operation Management: responsible for planning, managing and executing the transport services.
    - On-board management: is responsible for the safe and efficient operation of the transport means (e.g. navigation and adaption to traffic situation).
- The Transport Regulation domain: handles all regulations, including customs operations involved in the transport chain.
- The Transportation Area Management domain: arranges for safe, efficient and environmental friendly transport. It includes the management of the physical transportation network infrastructure (e.g. road, railways, fairways and terminal areas), traffic management (of traffic flows and individual transport means), and emergency management.
- The Transport Sector Support domain: provides generic services to the other domains, (e.g. different types of information services).

Deriving the Logistic for Life Framework

Freight transport and logistics are both processes that involve more than one partner. At the minimum, there is a transport, or logistics, services provider, and there is a buyer of the services. The commercial interaction between these two stakeholders is supported by interaction with the responsible for the transportation network, that is, where the transport or services are produced. The regulatory stakeholders, having an interest in that the planning and execution of the services are in alignment with laws and regulations, also support the commercial interaction. The practical implementation of the commercial interaction will also in many cases involve third party stakeholders supporting the processes and the information exchange. Thus, the main objective with a framework is to classify and relate knowledge on ICT for efficient and environment-friendly logistics with the strategic objective, so that based on this will be possible for a company to answer the question: What should be done to improve efficiency and sustainability? Secondly, it is necessary that the solutions can be assessed against strategic objectives. Consequently, measures needed for the sustainability and impact assessment needs to be defined. Based upon this, a company should also be able to identify solutions and technologies being most important for improvements within the company including the identification of relevant ICT standards and technologies.

Figure 4 shows the overall Logistic for Life Framework. This Framework uses the taxonomy already widely known in the transport sector, but it goes beyond that. The framework establishes the relation between the different layers, including the policy level, which comprises both policies defined by the European Commission, as well as commercial policies defined as strategic targets. Furthermore, it describes how the organization can impact on these targets by applying changes in their processes or by changing functions. The functional view plays a vital role, since the functions are the building bricks in the processes to be performed by the stakeholders in common, and hence, also for the information exchange. The functions of the freight transport, or logistics, service providers include both the long term and short term planning of the services, the marketing of the services, order handling, transport operation, tracking and status reporting as well as necessary completion actions. Finally, the bottom layer comprises the information and communication technologies which need to be implemented in order to support the changes at the logical level which are needed in an organisation in order to impact on their strategic targets.

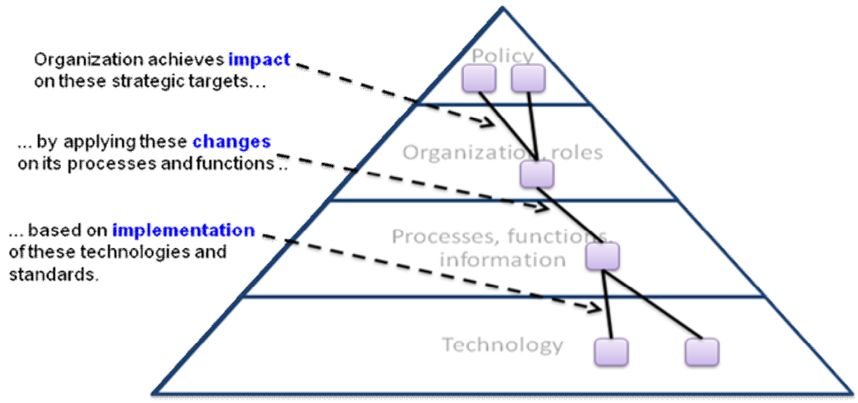


Figure 9: Logistic for Life Framework (source Insiel)

Challenges

The Logistic for Life Framework will offer a holistic description needed in order to help a company in searching for the right ICT solution for achieving their strategic goals regarding freight transport efficiency. However, up to now there have not been enough reliable results showing the impact of each function have on the different sustainability criteria. Thus, a first step is to identify the functions that can influence on the efficiency of freight transport and logistics. This will be done based upon the analysis of several projects having results that show that their solutions contribute to the sustainability dimensions. The analysis of these best practices is still in progress. This is however not enough. If the framework shall serve its intention, it is also necessary to identify what the different ICT technologies contribute to the sustainability, thus the second step is then to identify the possible use of ICT that can support these functions in influencing on the efficiency of the freight transport and logistics. Since the logistic processes are very complex and there is a lot of interrelation, this is quite complex. Each ICT can contribute to several strategies, and the impact does not only depend on the single technology but on the systemic effect, too.

CONCLUSTION AND FURTHER WORK

Freight transport and logistics are both processes that involve more than one partner. At the minimum, there is a transport services provider (*or* logistics service provider), and there is a buyer of the services. The transport or services are produced by the commercial interaction between the stakeholders. The regulatory stakeholders, having an interest in that the planning and execution of the services are in alignment with laws and regulations, also support the commercial interaction.

The Logistic for Life Framework addresses all these stakeholders and offers the possibility to assess already existing ICT based solutions for freight transport energy efficiency against the strategic objective of the stakeholder. With its layered approach it shows the indirect relation between ICT and strategic objectives. In this way, as soon as the framework is completely established, it will support decision makers representing e.g. freight carriers, logistic service providers and shippers in the decision making process regarding ICT functions. The framework will also provide authorities and policy makers with a tool to assess if solutions coming out of research project contribute to the sustainability criteria defined by the European Commission. Finally, the framework will guide future European policies by providing gap analysis on areas that lack ICT solutions and research activities and initiatives.

Keywords: Sustainability, green logistics, freight transport, framework

ACKNOWLEDGEMENTS

This work has been carried out in the context of the EU projects Logistics for Life

REFERENCES:

[1] http://engineers.ihs.com/news/eu-en-freight-transport-faq-10-07.html as of January 2011
[2] EU: European Economic and Social Committee on the European transport policy in the framework of the post-2010 Lisbon Strategy and the Sustainable Development Strategy (exploratory opinion) 28.12.2010 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:354:0023:0029:EN:PDF as of January 2011
[3] EU: European Commission: White paper: Roadmap to a single European Transport Area- Towards a competitive and resource efficient transport system, com(2011)144 final. Published 28.3.2011
[4]http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-2
[5] Tremove: http://www.tremove.org/documentation/TREMOVE_Short_Description.pdf, accessed 10. January 2011
[6] http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-2
[7] EU: Commission Communication "Innovation Union", COM(2010)546
[8] EU: Commission Communication on "A Digital Agenda for Europe", COM(2010)245/2.
[9]L4L:http://www.intelligentcargo.eu/sites/default/files/L4LIFE_general%20presentation_V01.pdf, accessed March, 12.2011, slide 11
[10] Lampe, W;Quandt, M.: "True greenness"- nachhaltige Logistik jenseits von Prozessoptimierung und CO_2-Kompensation, Industrie Management, 1/2011, S.12
[11] L4L: D1.3a requirement analysis. http://www.intelligentcargo.eu/content/public-documents
[12] http://people.hofstra.edu/geotrans/eng/ch8en/appl8en/ch8a4en.html
[13] Arktrans: Arktrans model;www.arktrans.no

POTENTIALS FOR TRANSACTIONS IN SUPPLY CHAINS – EFFECTS OF WEB-BASED INTERACTIONS IN THE MEDIA INDUSTRY

Christoph Illigen[1], Jörn Grapp[2], Michael Hülsmann[3]
[1]c.illigen@jacobs-university.de,[2]j.grapp@jacobs-university.de,
[3]m.huelsmann@jacobs-university.de
Jacobs University Bremen

INTRODUCTION

Budgets for movie and video-game production have risen over the last years from thousands to millions of USD forcing companies to invest much more to finish a product (PricewaterhouseCoopers 2010, Wirtz 2011, Entertainment Media 2010). Accordingly, elements of transaction costs like the frequency of information exchange between business partners are increased due to huge project teams demanding for more frequent information exchange (Dunniway 2009). Additionally, there are numerous other variable determinants causing complexity and dynamics during the development of a new product in the mentioned sectors (Hülsmann & Grapp 2006, Hülsmann & Grapp 2007, Grapp & Hülsmann 2008).

One approach has seemed to be promising for coping with the mentioned challenge and therewith to decrease transaction costs: Through the emergence of the internet and related new concepts like e-commerce companies expected a reduction of transaction costs due to a more efficient relation between all involved parties (Wirtz 2011). Consequently, web-based information exchange exhibits potentials to reduce transaction costs (Pereira 2005, Ebers & Kieser 2006, Williamson 2007). However, this concept also features risks like information overload due to more exchanged information (Pereira 2005). Therefore, the central objective of this paper is to identify and describe effects of web-based interactions towards transactions in order to reduce transaction costs illustrated for the supply chains in the movie and video-gaming industry. To accomplish this objective, the paper proceeds as follows: Section 2 introduces the supply chains of the movie and video gaming sector including their current challenges as they are intensively connected and have to cope with high and similar transaction costs. Section 3 describes the idea of web-based interactions as a digital and interactive solution approach to realise unused cooperation potentials. Transaction cost theory (TCT) will be introduced as a framework to explain cost-related supply chain effects. Section 4 discusses contributions and limitations of web-based interactions to reduce transaction cost-oriented problems. Section 5 will conclude the paper and provide a first idea for further research.

INCREASING CHALLENGES TO THE MOVIE AND VIDEO GAMES SUPPLY CHAINS

In the following, both supply chains of the movie and video gaming sector will be described regarding their main process steps as well as their dominating economic developments of the respective individual industries. The movie supply chain (i.e. block buster producers) consists of four steps, starting with the (1) procurement / pre-production (e.g. development of script) and followed by the (2) (post-)production (e.g. shooting of movie scenes). Afterwards, (3) rights and rental activities have to be operated (e.g. marketing) and finally (4) the distribution of the movie as media product (i.e. to cinemas and furthermore to the ancillary markets) have to be organised (Wirtz 2011). Movie production companies operating within the above described supply chain are confronted with a typical industry-originating problem context, characterised by financial and sales risks (Grapp 2009). Financial risks exist because the production phase is the most expensive part of a movie and therefore, the financial demand has to be forecasted already during pre-production (Picker 2001, Clevé 2004). However, there are sales risks as despite of market research the behaviour of potential movie consumers is hardly predictable (De Vany 2006, Sturm 2006). Hence, the resulting question is if movie producers are able to effectively develop ideas that fit to the needs of the viewers (Grapp 2009).

Wirtz (2011) divides the general video gaming supply chain into three steps: (1) development, (2) publishing and (3) distribution. In the development phase all activities around finishing the game as software itself like a game concept, programming, testing, balance work etc. take place. Thereby, the game is created. The next phase is the publishing and covers majorly the marketing but also takes care about licence management, producing saleable hard copies or financing of sales activities. This phase announces the finished game to the market. Finally, the last step distribution contains physical as well as online distribution. Thereby, the availability of the game titles either at wholesaler and department stores or on respective online platforms and download portals can be ensured and finally revenues can be generated (Wirtz 2011). During the whole process of game development involved companies are confronted with a couple of risks (e.g., Dunniway 2009, Morris 2010). First, there is the issue with financing the development. The developer or publisher has the whole financial risks during the development process, since the game does just cause costs and no returns during this process (Morris 2010). Accordingly, if the title fails the developer has a high loss through high production costs and low returns. The next problem is that a success prediction especially in a creative industry like the video gaming industry is very difficult. Thus, the risk of failure is even amplified, since through a hardened success prediction the potential of the game can hardly be estimated whereas the financial investments remain unchanged. Furthermore, the creation of new game concepts and ideas for new products is also one major challenge for the video gaming industry, since the success of games heavily depends of the fun factor, which is linked to the concept and ideas. Consequently, if ideas are good and new and are capable to interest the customer than the success of a game is somehow guaranteed whereas if the idea is unexciting and concepts don’t attract customers over a long time span the success of a game is in danger (Dunniway 2009).
In both media sectors of the movie and video gaming sector, development and production costs have significantly increased over the past years (Entertainment Media 2010). Therefore, promising cost-saving potentials between these two industries in order to cope with the identified development of increasing costs come into the centre of interest and could be revealed based on a closer perspective on their supply chains.

WEB-BASED INTERACTIONS AS A DIGITAL & INTERACTIVE SOLUTION APPROACH EXPLAINED BASED ON TRANSACTION COST THEORY

Internet can be characterised as ubiquitous. Numerous of diverse actors interact with each other which leads to complex interaction patterns. Some of the user´s priorities and services offered are emails, using search engines or video conferencing etc. (Wirtz 2011). However, where can web-based interaction be assumed in specific for developers and producers of the video gaming sector and the movie sector?

In the video gaming industry the so-called user behaviour tracking is applied usually in areas where users are directly connected to the game host (e.g., online and browser gaming). Thereby, it effectively collects data on user behaviour creating a basis for .e.g., developing better interfaces or performing usability-tests (Granka et al. 2004; Atterer et al. 2006). Thus, the production process can be adjusted to user expectations causing fewer rework and testing. For the movie industry, this paper follows the idea that active customers involved in so-called test screenings give online feedback on movie scenes. From a service-oriented perspective, potential viewers are invited to watch unreleased movies. During the screenings specific criteria have to be considered like a certain age structure or selected society layers. The goal is to evaluate to which extent a movie prospectively will satisfy the viewers’ needs (Schulze 2006, Wirwalski 2007, Grapp 2009).

TCT analyses companies by focusing on their transactions (e.g. Coase 1937, Williamson 1981). It thus serves as an explanation framework for differences in transaction efficiency of organisational interfaces and can be applied to support management decisions like make-or-buy decisions (Williamson 1981). Related costs can be divided into firstly ex-ante (e.g., negotiation costs) and ex-post costs (e.g., costs of contract updates) and secondly internal (e.g., controlling) and external costs (e.g., coordination of activities between corporations) (Picot 1982). Thereby, transactions exhibit different characteristics like frequency, uncertainness of environmental information, uncertainness of the transaction partner's information quality and economies of scope (Williamson 1981), which can hamper an appropriate decisions making. However, plenty of empirical studies have proven the reliability of analysis based on TCT (e.g. Picot 1991, Williamson 1991).

Through the application of TCT on web-based interactions like screening or user tracking cost saving potentials can be identified in the particular cost sectors of the TCT: First, costs involved in the ex-ante production process like negotiation costs or initiation costs can be reduced, since a more goal-oriented production reduces potentially user-/viewer irrelevant information by industry-spanning negotiations (e.g. content-related synergies through parallel game concept & script development based on tracking user/viewer preferences for specific scenes). Then, costs in the ex-post phase like costs of e.g., contract adaptations and updates are less likely, as through the more market-oriented development fewer rework costs will occur (e.g. due to screenings to identify connection errors in movies, which would be useful for a consistent and optimised game story-telling). Additionally, internal costs like administration costs can be reduced by working more focussed on the essentials of production, omitting irrelevant aspects and therewith optimising the whole production process (e.g. video-conferencing between script developers of movie & game designers). Finally, external costs like inter-firm activity-coordination can be improved by e.g., aligning marketing activities directly to customer needs (e.g. common marketing activities such as promotion on movie/video gaming portals).

DISCUSSION OF CONTRIBUTIONS & LIMITATIONS

This section discusses contributions of applying TCT on the web-based interactions (i.e., screening and tracking) for the cost category ex-ante based on its four characteristics. This category is chosen as an example, since it heavily affects all the others subsequent categories. Planning is assumed to be the decisive precondition for successful logistics processes as it provides the informational basis for a competent execution and production of media products (Grapp 2009). The frequency of ex-ante costs through tracking can be reduced, since the amount of information being exchanged is minimised leading to fewer total communication and less personnel involved. Only a few selected experts need to contribute to the creative production process and not a whole strategic planning department has to evaluate often complex customer preferences. Thereby, a more goal-oriented information procurement between minimum one media product developer of each industry (i.e. movie and gaming) is possible. To conclude, their decisions are based on an effective data collection, which is characterised by less complexity and an optimum degree of information (Hülsmann & Grapp 2006). A limitation is here, that legal issues (e.g. copyright) or technical restrictions (e.g. device to collect information) of the information being exchanged might hamper an effective web-based communication. Electronic data could eventually be misused by internet piracy which aims at unauthorised copying or use of intellectual property (Torr 2005). In this early stage of media product development, e.g. new ideas can be stolen easier as they are presented and exchanged online. The environmental uncertainty can be minimised by screening, since eliminating identified irrelevant story trees allows for a leaner budgeting, which consequently eases a forecast of the total financial commitment. On the contrary, a leaner total financial capacity also limits flexibility regarding eventual changes during production as maybe not all of the planned scenes in the movie script can be realised (Costanza 2004).

Quality uncertainties regarding the partner can be decreased by exchanging information gained through tracking, as this very close and specific information exchange enables for a better assessing of the partner's quality and consequently reduces according uncertainties. Both sides are part of one decision-making system (Cyert & March 1963) of media product development. On the other hand, this might also raise more questions due to more information finally increasing quality uncertainties, as e.g. the partner does not provide as much information as oneself or not in time which would of course decrease reliability. Screening might help to realise scale effects, since it can reveal logical breaks in a story, supporting game developers to learn from this errors and avoid a repetition of those. The generated learning effects can be used for common future projects and thereby generate a more sustainable product development (Kerth et al. 2007). On the other hand, this learning of gamers from the movie screening might limit the creative capacity of game developers, since they are very focused on the screening outcomes and omit potential alternatives, which are less and already seem to be predefined and substantiated so that no other and potentially also successful ideas are taken into account.

CONCLUSIONS & OUTLOOK

The main problem of the movie and the video gaming sector is that although they could benefit from each other they have not tried to analyse systematically how this could be attained. The key findings are that in the future there will be increased potentials for web-based interactions between the two media sectors leading to reduced transaction costs as shown above. This can be stated regarding a closer consideration of exemplifying transaction costs between the supply chains of these industries. This paper contains first assumptions how the web-based character of each media sector could contribute to one another. There are implications for research: First, the respective companies should focus on a detailed and comprehensive investigation of transaction cost categories, i.e. for all supply chain process steps, actors and interrelations to get a more profound perception of cost-reducing potentials. Second, they could try to make them accessible by studying cases on movie and video gaming projects. The implication for practice is that developing and producing games in connection with movies interactively has not been used to a larger extent as both media sectors still have to recognise, understand and open up themselves to an innovative thinking from the first moment of their creative product development on. Practice-related media experts have contrary opinions regarding this topic and are not sure themselves where the story goes. They e.g. think internet will just stay a channel for transporting information, however not attract interactive users who decide regarding differing story endings of movies or games. On the other hand, perhaps movie/game genres will mix up and new forms will result and vice versa will result from the internet (Jacobshagen 2008).

REFERENCES

Atterer, R. & Wnuk, M. & Schmidt, A. 2006, "Knowing the user's every move – user activity tracking for website usability evaluation and implicit interaction", *Proceedings of the 15th International Conference on World Wide Web,* Edinburgh, Scotland, pp. 203-212.

Coase, R. 1937, "The Nature of the Firm", *Economica 4*, no. 16, pp. 386-405.

Costanza, K. 2004, "How to Make a Hollywood Movie Under $800!", AuthorHouse, California USA.

Clevé, B. 2004, "Gib niemals auf: Filmökonomie in der Praxis", UVK Verlagsgesellschaft, Konstanz.

Cyert, R. & March, J. 1963, "A behavioural theory of the firm", Englewood Cliffs, New Jersey.

De Vany, A. 2006,"The movies – handbook of the economics of art and culture (part 1)", Amsterdam, pp. 615 - 665.

Dunniway, T. 2009, "Small developers: minimizing risks in large productions", Gamasutra Online, Accessed April 28th, 2011 < http://www.gamasutra.com/view/feature/4180/small_developers_minimizing_risks_.php>

Ebers, M. & Kieser, A. 2006, *Organisationstheorien,* Kohlhammer, Stuttgart.

Entertainment Media 2010, *Entertainment Guide 2010/2011,* G+J Entertainment Media GmbH, München.

Granka, A.G. & Joachims, T. & Gay, G. 2004, "Eye-tracking analysis of user behavior in WWW search", *Proceedings of the 27th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval,* Sheffield, UK, pp. 25-29.

Grapp, J. 2009, *Competence-oriented Potentials for Movie Production Logistics Management*, Gabler Verlag, Wiesbaden.
Grapp, J. & Hülsmann, M. 2008, "How to identify and analyse problems in global service supply chains? – concept of a competence-based tool for the logistics controlling in international network structures of the service sector", *Integrating the Global Supply Chain, Proceedings of 13th International Symposium on Logistics*, Loughborough, UK, p. 467.
Hülsmann, M. & Grapp, J. 2006, "Why do service logistics need self-organization? A competence-based analysis of global supply chains in the movie production industry" *Proceedings of the 4th International Logistics and Supply Chain Congress,* Baltacioglu, T. (eds.), Izmir, Turkey, pp. 370–378.
Hülsmann, M. & Grapp, J. 2007, "A competence-based analysis of collaboration in global service supply chains – design of a framework for the identification and evaluation of problems and options of logistics management in the service sector", *Proceedings of the 12th International Symposium on Logistics,* Loughborough, UK, pp. 299-305.
Jacobshagen, P. 2008, *Filmbusiness - Filme erfolgreich finanzieren, budgetieren und auswerten,* PPV Medien, Bergkirchen.
Kerth, K. & Asum, H. & Nührich, K. 2007, *Die besten Strategietools in der Praxis: Welche Werkzeuge brauche ich wann? – Wie wende ich sie an? – Wo liegen die Grenzen?,* Hanser Wirtschaft, München.
Morris, C. 2010, "As Video Game Development Costs Rise, So Do Risks", CNBC Online, March 2010, Accessed April 28th 2011 < http://www.cnbc.com/id/35932496/ As_Video_Game_Development_Costs_Rise_So_Do_Risks>.
Pereira, P. 2005, "Do lower search costs reduce prices and price dispersion?", *Information Economics and Policy,* vol. 17, no. 1, pp. 61-72.
Picker, G. 2001, *Kooperatives Verhalten in temporären Systemen – Eine empirische Analyse von Spielfilmprojekten in ihrem systemischen und dynamischen Kontext,* Duncker & Humblot, Berlin.
Picot, A. 1982, "Transaktionskostenansatz in der Organisationstheorie: Stand der Diskussion und Aussagewert", *Die Betriebswirtschaft,* vol. 42, no. 2, pp.267-282.
Picot, A. 1991, "Ökonomische Theorien der Organisation – Ein Überblick über neuere Ansätze und deren betriebswirtschaftliches Anwendungspotential", in: D. Ordelheide & B. Rudolph & E. Büsselmann (eds.), *Betriebswirtschaftslehre und Ökonomische Theorie,* Stuttgart, pp.143-170.
PricewaterhouseCoopers 2010, *German entertainment and media outlook: 2010-2014 – Die Entwicklung des deutschen Unterhaltungs- und Medienmarkts,* Fachverlag moderne Wirtschaft, Frankfurt am Main.
Schulze, P. 2006, " 'Ich habe totale Narrenfreiheit' – Zum Start des Director´s Cut von 'Königreich der Himmel' sprach Regisseur Ridley Scott über Testvorführungen und eine neue 'Blade Runner'-DVD", *Cinema,* no. 9, pp. 96-99.
Sturm, R. 2006, "Das Kreuz mit Tracking-Prognosen – Propheten mit Rechenschiebern", *Blickpunkt:Film,* no. 51 + 52, pp. 36-37.
Torr, J.D. 2005, "Introduction. At Issue: Internet Piracy. " Greenhaven Press, San Diego, Retrieved 26 April 2011. <http://www.enotes.com/internet-piracy-article/54083>.
Williamson, O.E. 1981, "The Economics of Organization: The Transaction Cost Approach", *The American Journal of Sociology,* vol. 87, no. 3, pp. 548-577.
Williamson, O.E. 1991, "Comparative economic organization: The analysis of discrete structural alternatives", *Administrative Science Quarterly,* vol.36, no.2, pp.269-295.
Williamson, O.E. 2007, "The economic institutions of capitalism. Firms, markets, relational contracting", *Das Summa Summarum des Management,* pp. 61-75.
Wirtz, B.W. 2011, *Medien-und Internetmanagement*, Gabler Verlag, Wiesbaden.
Wirwalski, A. 2007, "Feuerprobe Testscreening – Kalkuliertes Risiko", *Blickpunkt:Film,* no. 15, pp. 14-15.

SECTION 7 – ENVIRONMENTAL SUSTAINABILITY AND GREEN LOGISTICS

GREEN COLLABORATIVE PRACTICES IN THE SUPPLY CHAIN: AN EXPLORATORY ANALYSIS IN TERMS OF FORMS OF PROXIMITY

Valentina Carbone, Corinne Blanquart***
* ESCP Europe – Paris (France)
mailto: vcarbone@escpeurope.eu
** INRETS – Lille (France)
mailto: corinne.blanquart@ifsstar.fr

INTRODUCTION
The integration of the environmental dimension in the management of the Supply Chain (SC) can take different forms, beyond modal shift from highly polluting transport modes (road transport) to cleaner ones. More and more, collaborative practices are evoked, in the specialized press, like promising avenues for the integration of the environmental dimension in the supply chain.

Separately, several scholars have shown the possibility to effectively combine the set up of collaborative practices and the pursuit of an environmentally friendly supply chain, in particular with regard to the following SC stages: procurement, distribution, and reverse logistics (Preuss, 2001; Bowen et al. 2006; Sarkis, 2006; De Brito et al., 2008).

In France, and particularly for the textile and clothing industry, the Durlog project results (Blanquart et Carbone, 2008) confirm that companies initiate environmentally friendly supply chains as much in an individual way, through transport modal shift, than in a collaborative way, via voluntary sharing of logistics assets and transport means. Other works (Roure & Simonot, 2007) highlight short and long-term environmental advantages of collaborative practices in the supply chain, with a focus put onto collaborative freight transport initiatives (Pan et al. 2009).

Against such a rising concern for green collaborative SC practices, the aim of this paper is to show the diverse forms of collaborative practices and their related ways of integrating an environmental dimension. We presume that the prerequisites for greening the supply chain through collaborative initiatives can be of a different nature and consequently so is the adopted "green" solution. Seven case studies were analysed through 23 interviews carried out with the highest possible number of actors involved in the observed collaborative practices, referring to different stages of the supply chain (supply side, forward logistics, reverse logistics). We draw on "proximity economics", a theoretical framework at the crossroads of spatial and industrial economics. First, a typology of collaborative practices was developed and then it was characterised in terms of forms of proximity. Finally, a more *nuanced* comprehension of the link between collaborative practices and the environmental approach has been achieved.

COLLABORATIVE PRACTICES: HOW TO DEFINE AND ANALYSE THEM
We adopt the definition of Collaborative Supply Chain relying on the following characteristics " Two or more independent companies working jointly to plan and execute SC operations with greater success than when acting in isolation" (Simatupang and Sridharan, 2002). There is agreement in the literature about the dynamic nature of collaborative practices (Lambert et al. 1996; Fawcett et al. 2008). Simatupang et Sridharan (2002) show that collaborative practices are shaped across time following a life cycle from the engagement until the disengagement step. However, we assume that the

"time" dimension needs to be complemented by a "space" dimension, to effectively characterize the relationships among the actors involved in the collaborative practice.

Such an assumption is derived from the "proximity dynamics" literature stream, dealing with the coordination of economic and social activities by explicitly integrating their spatial dimension, and emphasizing the plural nature of the forms of proximity (Pecqueur and Zimmermann, 2004 ; Rallet, 1993 ; Torre, 2000). More precisely, the plural notion of proximity comprises three different dimensions:

- Geographical proximity, which refers to the physical distance existing among the actors, due to their different locations and areas of activity;
- Organizational proximity, concerning economic interactions between actors with complementary resources and participating in a same finalized activity through an inter-organizational arrangement;
- Institutional proximity, which is based on the participation to a common system of values and beliefs (Dupuy and Burmeister, 2003), as a result of repeated interactions, either of a business or of a social nature.

Drawing on the proximity dynamics literature, we conducted a comprehensive study of seven cases to better characterize the interactions within collaborative practices. The distinctive feature of our approach is to have involved most of the players participating in the collaboration, thus going beyond the limitations of a dyadic analysis applied to multi-actor inter-organizational arrangements. We have carried out as many semi-structured interviews as the number of actors involved in the collaboration (cf. table 1).

Cases	Collaborative practice	Industry/Sector	Interviews
1	Collaborative distribution of finished product	Fast Mover Consumer Goods	- 1 Logistics Service Provider - 1 Information System Pr. - 2 Manufacturer
2	Collaborative distribution of finished product	Fast Mover Consumer Goods	- 2 Manufacturers - 1 LSP - 1 Retailer
3	Collaborative distribution of finished product	Fast Mover Consumer Goods	- 2 Manufacturers - 1 LSP
4	Collaborative distribution of finished product	Fast Mover Consumer Goods	- 2 Manufacturers
5	New Product development, Purchasing	Specialized distribution	- 1 Specialized retailer - 1 Supplier
6	Collaborative provision of complementary industrial services, namely postponement, reverse logistics, refurbishing.	Logistics services	- 2 Industrial companies - 2 LSP - 1 Scholar
7	Collaborative Reverse logistics, comprising collection, recycling, refurbishing of Electric and Electronic Products.	Reverse logistics	- 1 LSP - 2 Manufacturers

Table 1 : List of case studies and interviews

This allowed us to compare different representations of the collaboration features and individual perceptions of the importance given to environmental issues. More precisely the interview guidelines (available on demand) were made up of two different sections : the first one aiming at describing the collaborative practice (involved actors, resources, activities, length of the contractual arrangement, perception of the rationales and performance of the collaboration), the second one aiming at analyzing the environmental dimension (role of the environmental constraint, objectives, results and monitoring system).

We analyzed the "time" (Simatupang et Sridharan, 2002) and the "space" dimensions of the inter-organisational interactions within each case. In this contribution, we focus on the "space" dimension exclusively. A typology of collaborative practices was outlined, in terms of different forms of interactions among the actors.

In line with previous literature (McKinnon et al., 2003), the different types of collaborative practices differ in terms of the following criteria: their belonging to the same or to different SC (*vertical collaboration* or *horizontal collaboration*) and the degree of complementarity or competition for products and services. Four "types" of collaborative practices are described by our life-cycle analysis framework (not presented in this paper) and characterized through different combinations of proximity forms (geographical, organizational, and institutional).

A TYPOLOGY OF SC COLLABORATIVE PRACTICES

The analysis of the cases allowed us to describe different types of collaborative practices (figure 1), who share similar "time" and "space" dimensions. These four types are:

a) The type "A" includes two *horizontal collaboration initiatives* (i.e. among actors belonging to different supply chains) where several producers of consumer goods, faced with increasing logistics constraints imposed by large retailers, switch from dedicated distribution networks to shared logistics solutions, where common physical parts of the supply chain are: means of transport and warehouses. These two initiatives rely on flow consolidation for compatible finished products in terms of common departure and destination points for final delivery to retailers. A neutral logistics service provider coordinates the consolidation scheme; very limited sharing information between producers is needed; a specific and detailed contract is put in place as for the governance issues.

b) The common feature in the type "B", in which there are still two *horizontal collaborative initiatives* and a *vertical collaborative initiative*, is a proactive strategy of actors, aiming either at taking advantage of the retailing increasing constraints, or at meeting the constant innovation requirements of some markets. The vertical collaboration concerns the co-design of new products, between a specialized brand-retailer and its supplier, whereas in the horizontal collaboration the shared logistics solution (cf. type A) is associated with a Vendor Managed Inventory approach (the retailer entrusts the management of its store inventories to the suppliers who had decided to consolidate their deliveries). In type "B" partners belong to a single chain or distribution channel. However, differently from previous cases, their products or services are complementary, allowing the extension of the perimeter of the collaboration. Accordingly, the essential difference with the first type is the higher level of information sharing among partners.

c) Types "C" and "D" include only one case each. Type "C" refers to the set up of an eco-organization in order to cope with the logistics complexity derived from the Waste Electrical and Electronic Equipment Directive (WEEE), which was introduced into law in January 2007 by the Waste Electronic and Electrical Equipment Regulations 2006. In this case, an inter-organizational arrangement among the main actors of the Industry entrusts a logistics service provider with the management of return flows on a pan European basis.

d) Finally, type "D" refers to a flexible associative structure, with a variable perimeter, including companies, academic and local institutions belonging to different domains and assembling complementary competencies. Such an inter-organizational arrangement stands as an innovative model for a new provision of services in a specific territory. The involvement of institutional partners feeds the project also with the ambition of contributing to local development.

	Competing products/services	**Complementary products/services**
Belonging to the same SC	Type A : A contract-based collaboration in response to retailing constraints *2 cases* o A reactive approach o A shared logistics solution for transport means and warehouse infrastructure o A logistics service provider as a neutral intermediary o Low level of information sharing o A very detailed contract *Geographical and organizational proximity*	Type B : Take advantage from the specific characteristics of the distribution channel *3 cases* o A proactive approach o An innovative way to cope with flexibility needs o Shared logistics solution and Vendor Managed Inventory, or co-design of new products o A logistics service provider as a neutral intermediary o High level of information sharing o Detailed operational rules *Geographical, organizational and institutional proximity*
Belonging to different SC	Type C : Optimized reverse logistics management *1 case* o To cope with the logistics complexity entailed by regulation o Set up of a dedicated collaborative organization o The leading actor: a logistics service provider o A wide spatial coverage *Organizational proximity*	Type D : A network organization to provide complementary industrial logistics services *1 case* o An associative structure multi competencies and skills, including institutional partners o A flexible structure with a variable perimeter o Very high information sharing among partners *Geographical, organizational and institutional proximity*

Figure 1: A typology of collaborative SC practices

The « space » dimension in terms of proximity

Each type of collaborative practices relies on different forms of proximity. For type A, the interactions between the actors rest on forms of geographical and organizational proximity. On the one hand, interdependences between partners are made possible by their proximity in space. The three initial partners had close warehouses, which initially allowed the *multipick*, and the choice of the last partner depended on the very close location of its warehouse to the one jointly selected by the beginners. On the other hand, in terms of organizational proximity, all the partners had to meet a certain number of conditions: common points of delivery, compatible frequencies, compatible sizes of batches, as well as a common logistics service provider.

In the case of type B, collaboration seeks to take advantage from the constraints and specificities of the channel of distribution and is articulated around the combination of the 3 forms of proximity: geographical, organizational but also institutional. An "optimum" common warehouse had to be defined. One of the partners stored already its goods on the selected site and the other actors managed to transfer their stock towards the new warehouse. As for organizational proximity, the same criteria of compatibility that for type A were present. Moreover, the partners share a common history or common values: in one case, two companies were taken over by the same group; in another case, two logistics managers from two different companies had worked for a former common employer; in the third case, the founders of the two partners were both oriented towards environmental values, both in their private and business life.

The organizational proximity supports collaboration, in type C. Companies are European or Global actors, without any particular geographical proximity. They voluntarily set up the conditions for their collaboration, by creating an eco-organization, and involving a leading logistics service provider, able to optimize reverse flow management on a European basis. The common will to anticipate regulations which founded collaboration is not sufficient to be described as institutional proximity, insofar as collaboration suffers from now on from a strategic lack of vision in the long run.

Finally, type D shows a double ambition: to propose an offer of complementary services to find new markets and, by doing this, to generate a dynamics of local development. This case combines 2 forms of proximity: on the one hand a high level of geographical proximity among the actors, all located in the same Area (industrial actors, institutional actors and a competitiveness cluster[1]); on the other hand, an organizational proximity, as actors deliberately set up the arrangement for their collaboration, i.e. the creation of the associative structure, the definition of the functioning rules, the financial support from an industrial and innovation cluster. Although before integrating the associative structure, the majority of the companies already had collaborated or tied interpersonal relations, the institutional proximity remains nevertheless to be built around the project, which has only started less than two years ago.

GREEN COLLABORATIVE PRACTICES: ONE SIZE FITS ALL?

Such cases, previously described in terms of forms of proximity, enables us to identify different methods for taking into account the environmental dimension in collaborative SC initiatives, which confirm that the answer to the environmental challenge is still neither univocal, nor simplistic. It is thus possible to illustrate three stories of green collaborative SC initiatives, each of them associated to a priority form of proximity. We left aside type "D", which does not seem to cover a sufficiently developed environmental dimension, probably due to its young age.

Institutional proximity built around a strong environmental orientation

Among the three forms of proximity, the collaboration of one of the cases (type B) mainly concerns the institutional proximity, in the sense that partners have shared for a long time a whole of common values and beliefs which facilitate their collaborative initiative as supplier and customer involved in the co-design of new products. The environmental orientation is indeed one of the core values within these two companies. Consequently their customer-supplier relationship is nourished by the same orientation, also because its objective is to design products respecting stringent environmental criteria which relate to the production process, the type of raw materials to be used (biological agriculture and fair trade), the quality and the traceability of the products.

---

[1] A competitiveness cluster is an initiative that brings together companies, research centers and educational institutions in order to develop synergies and cooperative efforts. (http://www.industrie.gouv.fr/poles-competitivite/brochure-en.html)

The supplier benefits derive from the acquired visibility over the year on the orders of his customer; this enables the supplier to optimize its own production and supply scheduling. Other advantages are as follows: its customer provides support for the purchase of environmentally friendly raw materials as well as a guarantee for favorable payment conditions. Thanks to such collaboration, the supplier developed a carbon footprint assessment project, relying on the customer expertise in this field.

The supplier actively contributed to the development of an application-software which makes it possible to obtain an overall assessment of the ecological footprint of a product according to a lifecycle approach, simplified in five stages (raw materials, manufacture, distribution, use and end of life). The customer is progressively extending the use of such software to other privileged suppliers for assessing the ecological footprint of the existing products and in two years it aims at applying such a screening tool as a preliminary step for any new product introduction. The application provides a detailed picture of each supplier (structure, environmental and social dimension, assets, certifications…) and of each product, through an evaluation of the social and environmental performance. It consists of a multiple-choice questionnaire adapted to each family of products (games/toys, wellbeing, art of living, garden, excursion, stationery products, jewels), and is centered around five impact indicators as for consumption of non renewable resources, energy consumption, environmental pollution and health impact, level of recyclability, and social risks related to the country of manufacture of the products. In this manner, the specialized retailer is anticipating the forthcoming obligation for environmental labeling. Each evaluation of product is summarized in a grade per each stage of product life cycle, which will make it possible to identify the main possibilities for improvement (reduction of packaging, replacement of plastic by renewable materials…). The customer commits himself to accompany suppliers in this improvement phase (obtaining certification, realization of the carbon footprint assessment…). The tool will also allow the retailer to select the more innovative suppliers for new product development in order to emphasize the environmental orientation of its catalogue

Geographical proximity and indirect positive environmental impacts

The cases belonging to type A put forward the importance of geographical proximity for the set up of horizontal collaboration, which requires that traditional competitors share warehouses, distribution centers and transport means for freight consolidation. Geographical proximity is needed to avoid detours that will ruin the consolidation scale effect (Ballot et al. 2010). Such freight consolidation is also able to produce positive environmental impacts. The respect of the environment is not among the triggers of the collaborative initiative, but it is one of its indirect effects, in particular in terms of reduction of CO2 emissions. Although the initial aim of partners is reducing their economic and financial costs, they declare: "We assume that if savings are realized, it will also generate a positive environmental impact". Increasingly, manufacturers and logistics service providers acknowledge the interest of integrating an environmental dimension to their freight organization, both for reducing emissions and improving the "green" image of their business. The natural convergence between transport optimization and green orientation is one of the most promising triggering factors for the enlargement of horizontal collaboration in the SC. As for the environmental impact, one of the projects of collaborative freight consolidation made it possible to divide by 2 the number of trucks on the road compared to the former situation, (292.000 km and 241 tons of CO2 saved). However these results are to be nuanced. One of the partners declared "the environmental impact of freight consolidation is however a very thin result… brought back to the 4,6 million km/year for all our flows".

Organisational proximity against regulatory constraints: a search for optimisation

In the collaborative reverse logistics case (type C), the environmental dimension was suggested by the promulgation of the European WEEE directive. The WEEE Directive aims to reduce the amount of electrical and electronic equipment being produced and to encourage everyone to reuse, recycle and recover it. The WEEE Directive also aims to improve the environmental performance of businesses that manufacture, supply, use, recycle and recover electrical and electronic equipment. The environmental impact is thus implicit in such an arrangement since collaboration developed to ensure the European management of waste related to the electronics and electric components! Nevertheless, the creation of the eco-organization for the management of return flows aimed at optimizing the recycling process on a global scale. Such an organizational proximity was created voluntarily by competitor actors having decided to anticipate the regulation in progress. They also decided to work with a leading logistics provider on a European scale, although such decision has been recently questioned by the eco-organization. It is the reduction of the economic and financial costs which is aimed by partners, however the environmental vocation of the regulation inevitably leads to some environmental effects.

The logistics provider had to sign the sustainability charter agreement provided by each partner of the eco-organization and has to make sure that waste is properly recycled. 90% of the collected waste is thus refurbished, dismantled and partially or totally recycled. Although the WEEE directive imposes a minimal collection rate, the logistics provider is incited to improve its collection performance thanks to the chosen rewarding system (proportional to the tons of collected waste).However, there is no specific objective as for the environmental impact, beyond the accidental convergence between transport optimization and a positive environmental impact.

On an initiative of the French Environment Ministry, with the support of ADEME (French Environment and Energy Management Agency), a specific charter on voluntary reductions of CO_2 emissions was drawn up last year to raise the awareness of road freight companies. The logistics provider working for the eco-organization wanted to mark its commitment by signing this charter alongside other major players in transport and logistics. Specific measures were adopted: updating the fleet with Euro 5 standard models, limiting top speed, training drivers on rational driving techniques with or without onboard IT systems, modal transfer and optimisation of transport plans.
This case can be interpreted as a confirmation of the Porter and Van der Linde thesis (1995), quite controversial in the literature, defending the idea that regulation would be a potential source for environmental innovation, when companies manage to transform the regulatory constraint (which usually favours a low compliance attitude from companies) into an opportunity for both business innovation and environmental protection.

CONCLUSION

This paper contributes to highlight the diversity of forms of collaborative practices in the supply chain and how these forms lead to different ways of integrating an environmental dimension. It provides a preliminary analysis of the preconditions for environmental collaborative practices in terms of forms of proximity among the involved actors. A more *nuanced* comprehension of the link between environment and collaborative practices has been achieved. A typology of collaborative practices was developed and it was characterised in terms of forms of proximity. On the one hand, geographical proximity alone is not a sufficient condition to foster collaborative practices integrating an environmental dimension, except for the natural convergence between transport optimization and positive environmental impact. On the other hand, organisational and institutional forms of proximity seem to be preconditions for effective collaborative environmental practices to a wider extent, each with peculiar characteristics.

Summarizing, the environmental dimension does not seem to be naturally integrated in voluntary collaborative practices in SC, on a large basis. Environmental collaborative practices have been put in place principally with the objective of reducing costs. Only one case (type B) definitely recognises the environmental dimension as one of the core elements of the collaboration, allowing collaborative value creation. Finally, it’s worth observing that most of the actors declare to be aware of the positive impact of environmentally friendly initiatives upon their own image in the marketplace. Accordingly they have now adopted the “green attitude”, i.e. proclaiming their concern for the environment. Green-washing or green-supply chain?

REFERENCES (8 PAGES MAX)

Ballot, E. & Fontane, F. (2010), Reducing greenhouse gas emissions through the collaboration of supply chains: lessons from French retail chains, Production, planning & control, 21, 640-650.

Blanquart C., Carbone V. (2008), La place du transport dans les organisations logistiques durables, Cahiers Scientifiques du Transport, N°54, pp. 11-24.

Bowen F.E., Cousins P.D., Lamming R.C. and Faruk A.C. (2006), Horses for courses: explaining the gap between the theory and practice of green supply, in Joseph Sarkis, Greening the Supply Chain, Springer-Verlag, London, 2006.

De Brito M. , Carbone V. and Meunier C. (2008), Towards a sustainable fashion retail supply chain in Europe: organisation and performance, International Journal of Production Economics, vol. 114, pp. 534–553.

Dupuy C., Burmeister A. (2003), Entreprises et territoires ; Les nouveaux enjeux de la proximité, Documentation française, mars

Fawcett Stanley E.., Magnan Gregory M., McCarter Mathew G. (2008), A three stage implementation model for supply chain collaboration, Journal of Business Logistics, January, pp. 1-14

Lambert D.M., Emmelhainz, M.A., Gardner, J.T. (1996), Developping and Implementing Supply Chain Partnerships, International Journal of Logistics Management, vol. 7, no 2, pp. 1-18.

McKinnon, A., Ge, Y. and Leuchars, D., (2003), Analysis of Transport Efficiency in the UK Food Supply Chain. Edinburgh: Herriot-Watt University

Pan, S., Ballot, E. (2009), The reduction of greenhouse gas emissions from freight transport by merging supply chains, International Conference on Industrial Engineering and Systems Management IESM’ 2009, Montréal Canada.

Pecqueur B., J.B. Zimmermann J.B. (2004), L’économie de proximités, Paris, Hermes-Lavoisier, 264 p.

Preuss, L. (2001), In dirty chains? Purchasing and greener manufacturing, Journal of Business Ethics, 34(3-4), 345-359.

Rallet A. (1993), Choix de proximité et processus d’innovation technologique, Revue d’Economie Régionale et Urbaine, n°3. 26-50.

Roure, J., Simonot, P.Y. (2007) Logistique collaborative : une question d’avenir, Paris, Economica, Ministère de l’Ecologie du Développement et de l’Aménagement Durable, 260p.

Sarkis, J. (2006), Greening the supply chain, London: Springer-Verlag.

Simatupang T.M., Sridharan R. (2002), The Collaborative Supply Chain, The International Journal of Logistics Management, Volume 13, N°1, pages 15-30.

Stefansson G. (2008), Supply chain interfaces: defining attributes and attribute values for collaborative logistics management, Journal of Business Logistics, January, pp.20-31.

Torre A. (2000), Economie de la Proximité et Activités Agricoles et Agroalimentaires, Revue d’Economie Régionale et Urbaine, n° 3, 407-426.

Whipple J.M., Russell D. (2007), Building supply chain collaboration : a typology of collaborative approaches, The International Journal of Logistics Management, Vol. 18, N° 2, pp 174-196

THE IMPACT OF ECONOMIC DEVELOPMENT ON THE ENERGY EFFICIENCY AND CO_2 EMISSIONS OF ROAD FREIGHT TRANSPORT

Heikki Liimatainen, Markus Pöllänen
Tampere University of Technology, Department of Business Information Management and Logistics, P.O. Box 541, 33101 Tampere, Finland, heikki.liimatainen@tut.fi, +358408490320

INTRODUCTION

The new White Paper for European Transport (COM/2011/0144) sets a 60 % greenhouse gas reduction target from the 1990 level by 2050 and a 20 % reduction from 2008 level by 2030. Well in line with the new targets, but based on the European Union's 20 by 2020 target and action plan (COM/2008/0030; COM/2008/0017), Finland set a target in 2008 of reducing 15 % of GHG emissions in the transport sector from the 2005 level by 2020 (MINTC 2009). Actions towards this target were set out for road freight transport in the energy efficiency agreement for freight transport and logistics, which included a 9 % energy efficiency improvement target by 2016 in accordance to the European energy services directive (2006/32/EC). In this study we only consider CO_2 emissions and exclude other greenhouse gases. By energy efficiency of road freight transport we denote the ratio between total haulage and energy consumption, indicated as ton-kilometers per kilowatt-hours [tkm/kWh].

In our national-level analysis of the Finnish energy efficiency agreement (Liimatainen & Pöllänen 2010) it was seen that the energy efficiency improvement and CO_2 reduction targets for road freight transport can in fact be contradictory. This was seen from the changes in energy use and energy efficiency from 2008 to 2009. As a result of the economic downturn the energy use (and the directly related CO_2 emissions) decreased close to the target but the energy efficiency also decreased, i.e. worsened, and was now further away from the target. A branch-level analysis was seen necessary to study these findings further.

Research on the impact of economic development on freight transport has focused mainly on national-level or international comparisons (see e.g. Stead 2001; Tapio 2005; McKinnon 2007; Kamakate & Schipper 2009). A few studies have also been made on branch-level and Kveiborg and Fosgerau (2007) note that distinction between industries is important, but further distinction between commodities within industries is not necessary. Sorrell et al. (2009) on the other hand study the road freight movements by commodity groups and conclude that the trends in each commodity group influence the aggregate trends greatly and may result in misleading conclusions on aggregate level. A common goal in these researches has been to find out whether decoupling has occurred and what changes have contributed to this. By decoupling the researchers have meant the slower growth of either ton-kilometres, energy consumption or CO_2 emissions compared to the growth of GDP or added value. Most studies found out that decoupling has happened and it has mainly been due to off-shoring industrial production, reduction in empty running and reduction in the fuel consumption of lorries.

It is evident that economic development in different branches of economy has a considerable effect on the development of energy efficiency and CO_2 emissions of road freight transport. Understanding these relations is essential when national and also international energy efficiency targets are set and evaluated. The key to this understanding is a detailed branch-level analysis. *The purpose of this paper is first to analyse what are the effects of differences between the branches of economy on energy efficiency and CO_2 emissions of road freight transport.* This analysis is done by combining statistical data related to road freight transport, energy use, CO_2 emissions and economic activity. Secondly, the key goal and purpose of this paper is based on this analysis *to describe how the economic development with regard to different sectors of economy affect the energy efficiency and CO_2 emissions of road freight transport in the future*.

METHODOLOGY

Combining energy data and road freight statistics

The main source for information on road freight transport in Finland is the continuous goods transport by road statistics, GTRS, which is compiled according to the European guidelines (Council Regulation 1172/98) and is thus comparable with the statistics of other European countries. For Finland there are comparable statistics available from year 1995. The GTRS lack any direct data on energy consumption or CO_2 emissions, unlike e.g. the respective statistics in the UK (DfT 2010). In order to analyze the energy and CO_2 efficiency in Finland the road freight statistics need to be enhanced with energy consumption data. The method for doing this was presented in Liimatainen & Pöllänen (2010). By using this method each journey reported in the GTRS is given an estimated fuel consumption based on the gross vehicle weight, age of the vehicle and the type of road on each journey. Thus energy consumption and CO_2 emissions can be analyzed in the same way as other indicators in the statistics, allowing sectoral analysis.

Classifications

Sectoral analysis is based on grouping the types of commodities under chosen branches. There were 40 types of commodity in the GTRS in 1995, 42 between 1996 and 2007 and 45 in 2008 and 2009. The changes in the types of commodities are minor and mostly just divide previous ones to sub-categories, which still belong to the same sector, but can yet cause some inaccuracy in the analysis. The sectors are established from the ones used in the national accounts. These categories have also changed between 1995 and 2009 but the statistics have been adapted to ensure comparable time series. It should be noted that, because of the sampling, the data is limited at the branch-level and this may cause some random variation to this analysis, which is the case even at the national level.

Matching the types of commodities to sectors, as presented in Table 1, is not an unambiguous task. Many commodities can be assigned to both manufacturing and trade sector. Our solution is to divide those commodities to both of sectors according to the answer the respondent has given to the question regarding its primary customer: is it industry, trade or public sector? For each commodity type the share of journeys for which the primary customer is stated to be trade is assigned to trade and the rest to the corresponding manufacturing sector. Also the service sector is problematic as none of the commodities can be assigned solely to services. Transports for service sector are also quite often managed by manufacturers or wholesalers. Because of this we exclude the service sector from this analysis. This also means that that large share of economical output measured by gross domestic product (GDP) is excluded. For Finland the share of different services (such as health and social services, education, financial and insurance activities) of GPD in 2009 was 48 per cent, yet - because of the nature of these branches - there is only very little to transport related to these services.

Sector	Commodities	National accounts sectors
Forest cluster	Raw wood, wood products and paper	Forestry, manufacturing of wood products, mfg of paper products
Food cluster	Agricultural products, animals food products	Agriculture, hunting, fishing, mfg of food products
Energy cluster	Solid and liquid fuels	Mfg of oil, coke and nuclear fuel; supply of electricity, gas and water
Construction cluster	Asphalt, soil, building materials	Construction
Technology cluster	Ore, scrap metal, metal products, machines, appliances, vehicles	Mining, mfg of metal products, machines, appliances, electrotechnical products and vehicles
Chemical cluster	Chemicals, medicines	Mfg of chemiclas and chemical products
Other manufacturing	Furniture, clothes, glass and plastic products, unidentified goods	Mfg of textiles, clothes, leather, rubber and plastic products, non-metallic mineral products, other mfg and recycling
Waste and maintenance	Waste, empty containers, packaging materials, maintenance	Other public and household services inc. waste collection
Trade	Fruits, furniture, food products, appliances, clothes, glass, empty containers packaging materials, unidentified goods	Trade; wholesale and retail, repairs of vehicles and household appliances

Table 1: Assigning the commodities (GTRS) and national accounts sectors to sectors analyzed in this paper.

Analyzing the empty running by sector
Empty running is one type of commodity in the commodity classification and thus it cannot be directly assigned to any sector. Sorrell et al (2010) also highlighted this as an important deficiency of national statistics as it prevents the analysis of empty running by commodity group and vehicle type. In this analysis the empty running can, however, be studied by sector and vehicle type. This is enabled by first dividing the amount of vehicle kilometres run empty to different types of cargo space and cargo handling equipment (15 types in total, e.g. curtainsided, refrigerated box, flatbed or waste compactor). Also the total laden vehicle kilometres are then divided to cargo space types and the share of empty running calculated for each type of cargo space. Laden and unladen kilometres by types of cargo space are then divided to sectors. For each sector the total laden and unladen kilometres are calculated out by adding up the kilometres of each type of cargo space. Each sector utilizes the types of cargo space differently (e.g. timber trucks are used only in forest cluster) so the overall level of empty running varies between sectors according to the kilometres driven with different types of cargo space.

DECOUPLING BY SECTOR

Results from the decoupling analysis, using the Tapio's (2005) decoupling definitions, are presented in Table 2. Overall, there has been weak decoupling of transport volume and CO_2 emissions from the economic development in Finland between 1995 and 2009. The Finnish economy currently produces considerably less CO_2 from road freight compared to its added value than 15 years ago (40 g/€ in 1995, 28 g/€ in 2009). However, in terms of energy efficiency there has been no improvement (3.26 tkm/kWh in 1995, 3.27 tkm/kWh in 2009), i.e. the there has been expansive coupling between energy use and transport volume.

The overall situation conceals dramatic changes between and within the sectors. These changes can largely be attributed to the shift of balance from transporting bulk goods to transporting unitized goods. Bulk transport clusters such as forest, construction, energy, and chemical, are responsible for the majority of freight transport demand in Finland, but their transport is also very energy efficient. Road freight transport in these sectors produces considerably less CO_2 per ton-kilometre than e.g. transport in technology cluster, trade or waste and maintenance. This shift has been driven by diminishing importance of forest cluster and growing importance of technology cluster, other manufacturing and trade. The forest cluster had 20 %, 31 % and 23 % share of added value, transport volume and CO_2 emissions, respectively, in 1995. By 2009 these shares had dropped to 14 %, 22 % and 15 %.

The added value of technology cluster has almost tripled while the transport volume has decreased by one fourth and energy use and CO_2 emissions by 11 %. However, some of the growth of transport volume in other manufacturing may be explained by the economic growth in technology sector. This is because other manufacturing includes transporting unidentified goods, e.g. containerized goods and mixed pallet loads, and technology cluster uses increasingly these kinds of less-than-truckload transports with mobile phones and other valuable small goods. As a matter of fact, unidentified goods comprised 6 % of total ton-kilometres in 1995 but as much as 14 % in 2009. Their share of ton-kilometres in other manufacturing has risen from 67 % to 75 %. Hence, it is best to analyze technology cluster and other manufacturing together. Together these sectors are the second biggest in terms of ton-kilometres and biggest in terms of energy use and CO_2 emissions in 2009. The analysis shows that there has been 133 %, 36 % and 38 % increase in added value, transport volume and CO_2 emissions, respectively. This means weak decoupling of transport volume and CO_2 emissions from the economic development and expansive coupling between energy use and transport volume, similarly to the overall development in Finland.

1995-2009	Forest cluster	Food cluster	Energy cluster	Construction cluster	Technology cluster	Chemical cluster	Other manufacturing	Waste and maintenance	Trade	Total w/o services
Share of added value 1995 --> 2009	20 % --> 14 %	9 % --> 7 %	5 % --> 4 %	13 % --> 11 %	19 % --> 33 %	3 % --> 3 %	6 % --> 4 %	8 % --> 6 %	19 % --> 17 %	100 %
Share of tkm 1995 --> 2009	31 % --> 22 %	14 % --> 11 %	7 % --> 7 %	18 % --> 17 %	9 % --> 6 %	6 % --> 5 %	6 % --> 12 %	2 % --> 5 %	8 % --> 15 %	100 %
Share of energy and CO2 1995 --> 2009	23 % --> 15 %	14 % --> 10 %	6 % --> 6 %	16 % --> 15 %	9 % --> 7 %	4 % --> 3 %	8 % --> 15 %	6 % --> 10 %	12 % --> 19 %	100 %
Change in added value	11 %	20 %	33 %	36 %	170 %	78 %	7 %	26 %	37 %	54 %
Change in tkm	-24 %	-10 %	12 %	5 %	-24 %	-15 %	122 %	135 %	103 %	9 %
Change in energy use and CO2 emission	-27 %	-20 %	4 %	-2 %	-11 %	-20 %	93 %	65 %	70 %	8 %
Added value elasticity of tkm	-2.29	-0.53	0.37	0.14	-0.14	-0.19	18.02	5.08	2.75	0.16
	strong decoupling	strong decoupling	weak decoupling	weak decoupling	strong decoupling	strong decoupling	expansive negative decoupling	expansive negative decoupling	expansive negative decoupling	weak decoupling
Added value elasticity of energy and CO2	-2.60	-1.01	0.13	-0.07	-0.07	-0.25	13.67	2.44	1.88	0.15
	strong decoupling	strong decoupling	weak decoupling	strong decoupling	strong decoupling	strong decoupling	expansive negative decoupling	expansive negative decoupling	expansive negative decoupling	weak decoupling
Tkm elasticity of energy and CO2	1.13	1.91	0.36	-0.50	0.47	1.33	0.76	0.48	0.68	0.96
	recessive coupling	recessive decoupling	weak decoupling	strong decoupling	weak negative decoupling	recessive decoupling	weak decoupling	weak decoupling	weak decoupling	expansive coupling

Table 2. Decoupling of transport volume from economic growth, energy use and CO2 emissions from economic growth as well as energy use and CO2 emissions from transport volume in Finland by sector 1995-2009.

REASONS FOR DECOUPLING

Transport intensity

The relationship between transport volume and economic activity is named transport intensity. Here the road freight transport volume is measured in tonne-kilometres (tkm), and the economic activity as value added (euros), which is a sectoral value connected to the GDP. Thus the unit measuring transport intensity is here tkm/euros. Transport intensity is determined here by two key ratios: value density and average length of laden trips. Other possible key ratios include modal split and handling factor, but there is no information available to calculate handling factor. Modal split has been very stable in Finland during this time, road share of transported tons has been between 88.6 % and 90.0 %, and so modal split has not affected the changes in transport intensity.

Value density is the ratio between value added and road tons moved (€/t) and increasing value density in almost all sectors is the main reason for the decreasing transport intensity. Value density has increased in all sectors except in other manufacturing, trade and waste and maintenance. Overall the value density has increased by 81 % and the development has been driven by the 173 % increase in the technology cluster.

The average length of laden trips has increased slightly in all sectors except food cluster and technology cluster. Lengthening trips increase transport intensity, but the effect of this is overruled by the huge increases in value densities.

Figure 1 summarizes the changes in value density and average length of laden trips, by showing the level of these in 1995, 2002 and 2009. Year 2002 is the middle year in our time series, but it is also the year in which the total energy consumption and CO_2 emissions were at their highest level and also the energy efficiency was at its highest level. In Figure 1 the sustainable development, i.e. decreasing transport intensity, is happening when the arrow is pointing towards upper left corner, i.e. value density increases and length of laden trips decreases. This has been the case in technology cluster and food cluster.

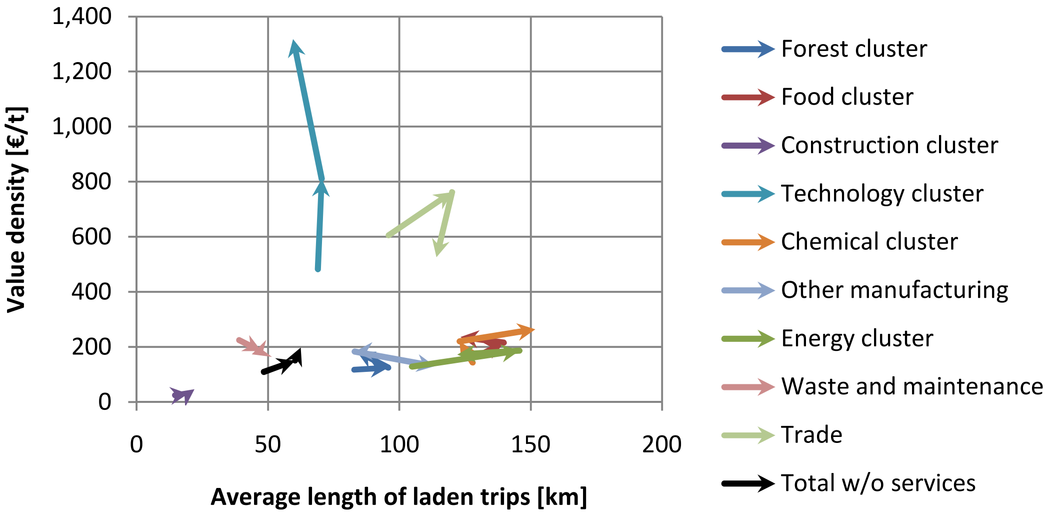


Figure 1. Development of value density and average length of laden trips by sector. The starting point of the arrow for each sector is the value for the year 1995, turning point is the value for year 2002 and end is the value for year 2009.

Vehicle utilisation

Vehicle utilisation is analyzed by the weight-based vehicle utilization rate and the level of empty running. Vehicle utilization determines how much mileage is needed to transport the ton-kilometres demanded by the economy. Thus it also affects the energy efficiency. Sectoral differences are evident in the vehicle utilization, presented in Figure 2. The sectors carrying mostly bulk goods are construction, energy, chemical and forest clusters. These are characterized by high utilization rate and average load, but also relatively high level of empty running. The sectors carrying general cargo are technology cluster, other manufacturing and trade. These are characterized by low utilization rate, small load and fairly low level of empty running. Food cluster is between the two aforementioned with fairly high utilization rate and average load but relatively low empty running. Waste and maintenance has very low utilization rate and fairly high level of empty running.

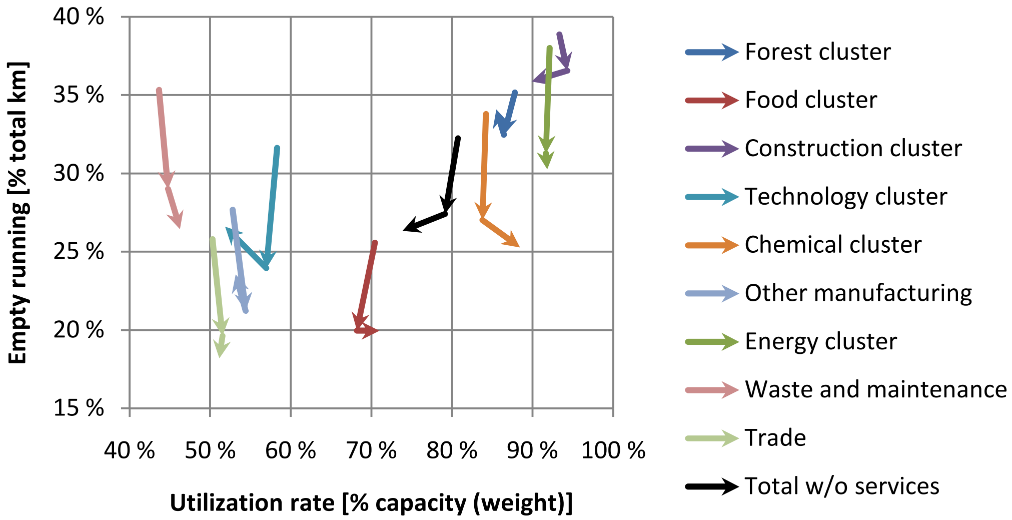


Figure 2: The development of empty running and average load on laden trips by sector. The starting point of the arrow for each sector is the value for the year 1995, turning point is the value for year 2002 and end is the value for year 2009.

When studying the development over time with regard to empty running and vehicle utilization rate, we can see in Figure 2 a clear trend towards lower empty running on every sector between 1995 and 2002. After 2002 however, empty running has increased in forest cluster, technology cluster and other manufacturing. Also in every other sector the improvement has slowed down. For utilization rate there is more mixed development, as for some sectors the utilization rate has dropped, e.g. construction and technology cluster, and for some raised, e.g. chemical cluster and waste and maintenance.

In Figure 2 the sustainable development, i.e. more efficient utilization of vehicles, is happening when the arrow is pointing towards bottom right corner. i.e. when empty running is decreasing and utilization rate increasing. This has been the case in many sectors, but as for the biggest and most important sectors (technology, forest, construction and food clusters and trade), trade and food cluster show slightly improving utilization rate and others clearly declining utilization rates. It can be concluded that the decreasing empty running is overruled by worsening weight-based utilization rate and thus the ratio ton-kilometres per total mileage (tkm/km) has decreased resulting in unsustainable development.

Vehicle fuel consumption

Vehicle fuel consumption determines how much energy is used and CO2 emitted in driving the total mileage. Fuel consumption is a result of many interacting determinants, including vehicle's own weight, powertrain technology, aerodynamics, driver's behaviour, and traffic conditions. However, there is data on only some of these attributes. In our analysis the fuel consumption is calculated based on vehicle's gross weight and Euro-class and type of road (for further details see Liimatainen & Pöllänen 2010). Figure 3 summarises the changes in the share of urban mileage and fuel economy factor, which is based on Euro-classes. The sustainable development would be towards bottom left corner, i.e. less fuel consuming urban kilometres with vehicles of low fuel consumption. All sectors have renewed their vehicle pool towards less consuming lorries, although the speed of the change has varied between sectors. In terms of urban mileage forest cluster is the only one with decreasing share. Improvements towards less consuming vehicles are partly offset by increasing share of urban mileage. Also decreases in the vehicle gross weights decrease fuel consumption and as a result the overall average consumption has decreased from 35.1 l/100km in 1995 to 33.6 l/100km in 2009.

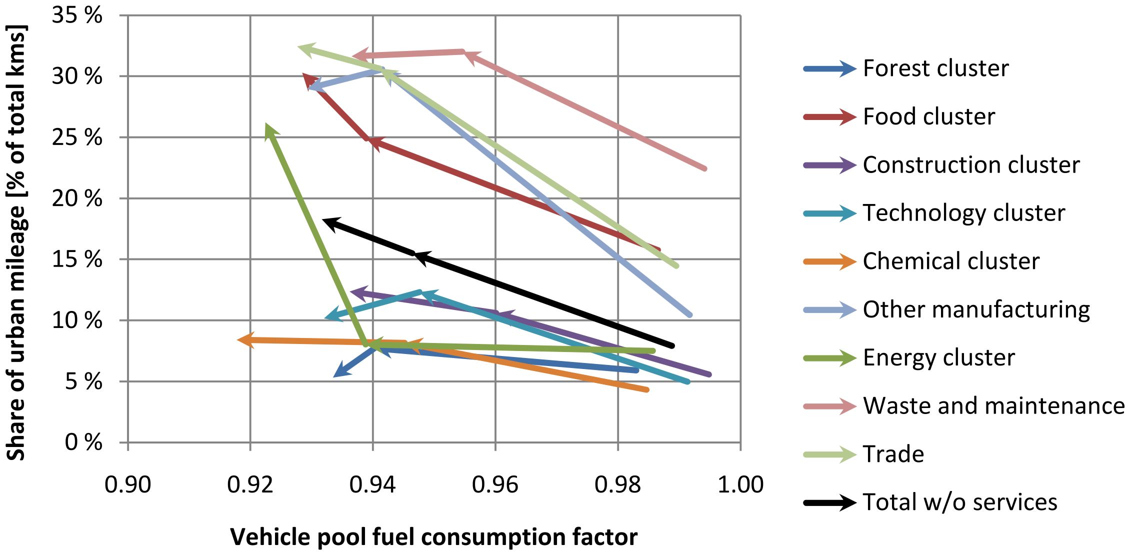


Figure 3: The development of share of urban mileage and vehicle pool fuel consumption factor by sector. Each EURO-class has different fuel consumption factor (1 for pre-Euro, 0.931 for Euro 1, 0.924 for Euro 2, 0. 948 for Euro 3, 0.899 for Euro 4, 0.909 for Euro 5) and the factor for vehicle pool is the weighted average of the share of mileage driven with each Euro-class. The starting point of the arrow for each sector is the value for the year 1995, turning point is the value for year 2002 and end is the value for year 2009.

DISCUSSION AND CONCLUSIONS

The balance of sectoral economic development has a great impact on the energy efficiency and CO_2 emissions of road freight transport. Bulk goods sectors (forest, construction, energy, chemical) are transport intensive and energy efficient and a shift in balance towards these sectors would improve the energy efficiency of road freight operations but also rapidly increase the overall CO_2 emissions. A shift towards sectors using unitized loads (technology, other manufacturing, trade) would result in worsening energy efficiency and more slowly increasing or even decreasing CO_2 emissions. The economic development in Finland from 1995 to 2002 was characterized by growth in all sectors, which led to growing CO_2 emissions and improving energy efficiency. Economic development from 2002 to 2009, on the other hand, saw diminishing importance of forest cluster and growing importance of technology cluster and trade. This has led to diminishing CO_2 emissions but also diminishing energy efficiency.

As a conclusion of our analysis, the future of road freight energy efficiency and CO_2 emissions is greatly affected by the economic development of each sector. There are many organizations providing sectoral economic forecasts, which could be used in forecasting the energy efficiency and CO_2 emissions of road freight by extrapolating the trends of the determinants presented in this paper. These forecasts could then indicate whether the national energy efficiency and emission targets will be achieved or not. However, in the short run policymakers have very little chances to control the economic drivers (such as price of labour and energy, access to raw materials, level of technology and knowledge), which in the end determine the sectoral economic development and thus the need and efficiency of road freight operations.

The research presented a new method for analysing the relations between economic activity, transport demand, energy efficiency and carbon dioxide emissions with a great level of detail. This was done by using the statistics that are available in many countries and are gathered in a harmonized manner in the EU member states. Hence, the method is applicable in other countries and enables in-depth comparison between countries.

REFERENCES

COM/2008/0017. Proposal for a decision of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

COM/2008/0030. 20 20 by 2020 - Europe's climate change opportunity.

COM/2011/0144. White paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.

Council Regulation 1172/98. Statistical returns in respect of the carriage of goods by road.

Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

DfT 2010. Transport Statistics Bulletin. Road Freight Statistics 2009. Department for Transport, United Kingdom. [http://www.dft.gov.uk/adobepdf/162469/221412/221522/222944/661202/rfs2009.pdf]

Kamakate, F., Schipper, L., 2009. Trends in truck freight energy use and carbon emissions in selected OECD countries from 1973 to 2005. Energy Policy. Vol 37. Issue 10. pp. 3743-3751.

Kveiborg, O., Fosgerau, M. 2007. Decomposing the decoupling of Danish road freight traffic growth and economic growth. Transport Policy, Vol. 14, pp. 39-48.

Liimatainen, H., Pöllänen, M. 2010. Trends of energy efficiency in Finnish road freight transport 1995-2009 and forecast to 2016. Energy Policy, Vol. 38, Issue 12, pp. 7676-7686.

McKinnon, A. 2007. Decoupling of road freight transport and economic growth trends in the UK: an exploratory analysis. Transport Reviews, Vol. 27, Issue 1, pp. 37-64.

MINTC 2009. Climate policy programme for the Finnish Ministry of Transport and Communications' administrative sector for 2009-2020. (in Finnish, English summary) [http://urn.fi/URN:ISBN:978-952-243-065-6]

Sorrell, S., Lehtonen, M., Stapleton, L., Pujol, J., Champion, T. 2009. Decomposing road freight energy use in the United Kingdom. Energy Policy, Vol. 37, pp. 3115-3129.

Sorrell, S., Lehtonen, M., Stapleton, L., Pujol, J., Champion, T. 2010. Decoupling of road freight energy use from economic growth in the United Kingdom. Energy Policy, doi:10.1016/j.enpol.2010.07.007.

Stead, D. 2001. Transport Intensity in Europe - indicators and trends. Transport Policy, Vol. 8, pp. 29-46.

Tapio, P. 2005. Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001. Transport Policy, Vol. 12, pp. 137-151.

A CONCEPT TO EVALUATE RESOURCE AND ENERGY EFFICIENCY THROUGH AN UTILIZATION-BASED SIMULATION FOR ANTICIPATORY CHANGE PLANNING OF INTRALOGISTICS SYSTEMS

André Wötzel[1], Gerhard Bandow[2]
[1] TU Dortmund University
[2] Fraunhofer-Institute for Material Flow and Logistics & TU Dortmund University

ABSTRACT
The dynamics of the markets requires intelligent logistics and production concepts as well as adaptable logistics and production structures and systems. Besides, the management of a company strives to avoid every kind of waste as well as for a continuous improvement of concepts, structures and systems. Regarding to this the efficient use of resources and energy are more and more important. Especially the scarcity of natural resources and rising energy costs are great challenges for the future. Nevertheless, most of the intralogistics systems are oversized [1] and waste an immense amount of resources and energy. But these systems have to work efficiently because of the high assets and operating costs. In this context the following questions have to be answered: "What does efficiency mean for intralogistics systems?" and "How can an utilization-based simulation contribute to efficiency?". This paper presents a theoretical concept and procedure to evaluate efficiency through an utilization-based simulation for Anticipatory Change Planning of intralogistics systems.

INTRODUCTION
Most production companies do not have a core competence in utilizing intralogistics systems[2]. Due to less competence or knowledge within a production company, the utilization of these expensive systems (in operating and investing) is not efficient (e.g. less resource input by optimal operation). Furthermore, intralogistics systems are mostly inflexible and have long useful economic life. During this time the dynamic changes of the utilization of intralogistics systems are to be considered. Usually, the planning horizon for intralogistics system is about 20 years. After this time the systems is modernized. The modernization allows a further useful life for at least 15 more years [1]. Today, there are more than 10,000 intralogistics systems in Germany. For these systems the demand for an efficient utilization is enormously high during their useful life [2, 3]. Due to this demand, the potential for "right" dimensioning as well as operating of intralogistics systems is logical. Furthermore, most of the intralogistics systems are oversized because of a high requirement for reliability and availability [4, 5, 6]. In this context the actual planning and design rules of intralogistics systems have to change because of the increasing economical and ecological requirements (reduce waste, resource input, and energy).

Operating intralogistics systems includes dynamic changes, which require the utilization of the implemented capacities to be changed. These capacities are mostly limited [cf. 7]. Due to the capacity limitation, excessive-loads or under-loads (e.g. bottlenecks / failure) can result in a decrease of the economical performance and reliability of intralogistics systems as well as the production systems. Triggers for dynamic changes (change drivers or planning initiations) of these systems are [8, cf. 9]:

- changes of the system load (new products, new production outputs, new diversifications, etc.),
- cost pressure (productivity, asset, capacity utilization, etc.) or
- changes in services (delivery time, delivery reliability, etc.).

The three planning initiations can affect a logistics or supply network, a single location or a single system.

---

2 "Intralogistics comprises organization, controlling, execution und optimization of the in-house material flow, information flow as well as handling in industry and trade companies as well as public facilities" [10]

The intention is to recognize the dynamically changing requirements of the efficiency of an intralogistics system (which are induced by a production system) at an early stage. Due to the early recognition, a pro-active implementation of adequate countermeasures is possible, which guarantee the demand-based operation of intralogistics systems. For the realization of this objective, simulation models are necessary. These models allows to simulate the different utilization degrees of the particular capacities of an intralogistics system depending on the system load (the flow of objects entering a system or a number of objects entering a socio-technical system in a given time period [cf. 11]). An utilization-based simulation is necessary in order to derive the essential demand of change from these results and to determine sensible economical as well as resource and energy efficient measures for the system change. Alternative system changes also have to be verified by a utilization-based simulation in order to determine the best solution under the given basic conditions as well as a basis for evaluating the efficiency of intralogistics systems. Thus, it can be achieved that the changeability of a production system will induce an economical as well as a resource and energy efficient adaption of the corresponding intralogistics system.

EFFICIENCY

Efficiency is used very heterogeneous in scientific literature. In business sciences, efficiency is associated with profitability or productiveness of an enterprise. "Technically efficiency" is mostly understood as energy efficiency. This means low energy input for a production system which is used to capacity [12]. In spite of the different views a common characteristics can be identified. Efficiency is a relation between input and output or between costs and benefit. Due to this missing definition of efficiency of an intralogistics system, our own definition will be adapted:

The efficiency of an intralogistics system is a relation between the reached input (fulfilment of the demanded system load) and the utilization-based output (driving power, degree of wear out, operating time, etc.) of intralogistics components – and resultant – of the whole systems.

One reason for intensive and fundamental research of intralogistics systems is the waste of energy by roller conveyors. It is possible to reduce the waste of energy in an industrial environment by about 30 % [13]. To recognize this high potential it is necessary to develop tools for the evaluation and visualisation of the efficiency of intralogistics systems.

UTILIZATION-BASED SIMULATION FOR ANTICIPATORY CHANGE PLANNING OF INTRALOGISTICS SYSTEMS

The resource and energy efficiency of existing intralogistics systems can be evaluated with an utilization-based simulation tool. Therefore, the ACP is a simulation-based concept. It ensures reliable, effective, and efficient operation of logistics systems, factories, or networks in a continuously changing and dynamic business environment [cf. 2, 6]. The concept integrates a range of activities for the anticipatory identification of changes of capacities in logistics systems as well as for the selection and planning of adequate countermeasures. The basic parameter for the ACP is the anticipated system load. The utilization-based simulation for the ACP of intralogistics systems is a model-based software tool to determine the need for change and to scrutinize the adequacy of selected measures in response to the anticipated system load.

The Anticipatory Change Planning is embedded in a structured procedure which consists of several stages (partially iterative). Figure 1 visualizes the stages and their respective tools within the ACP.

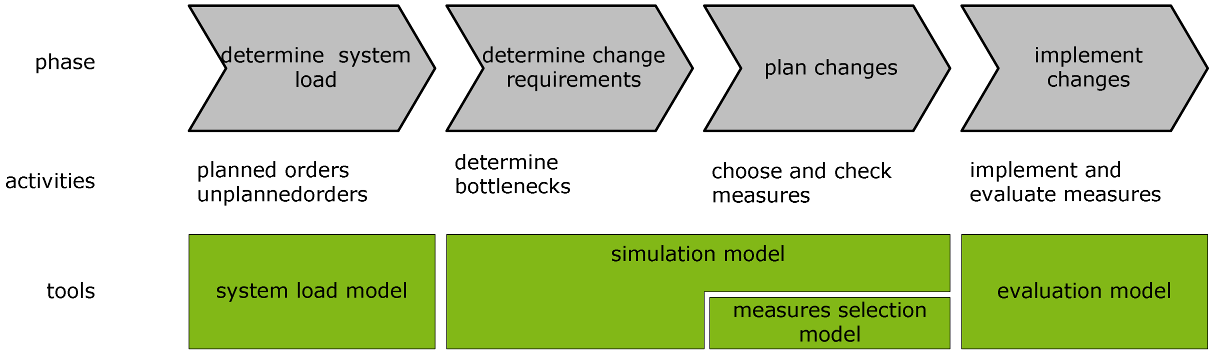


Figure 1: stages and tools for anticipatory change planning [cf. 14]

The utilization-based simulation is the basic tool of the ACP. Based on a simulation model of the intralogistics system, the needs for change can be determined. These needs are the input information to select measures to compensate the existing bottlenecks and to check with regard to their suitability (ascertained by the measure selection model [cf. 15]). With its different filters (cost filter, quality filter, etc.) the measure selection model supports a structured search for one or a bundle of compensation measures. These measures lie in a flexibility and performance corridor (figure 2).

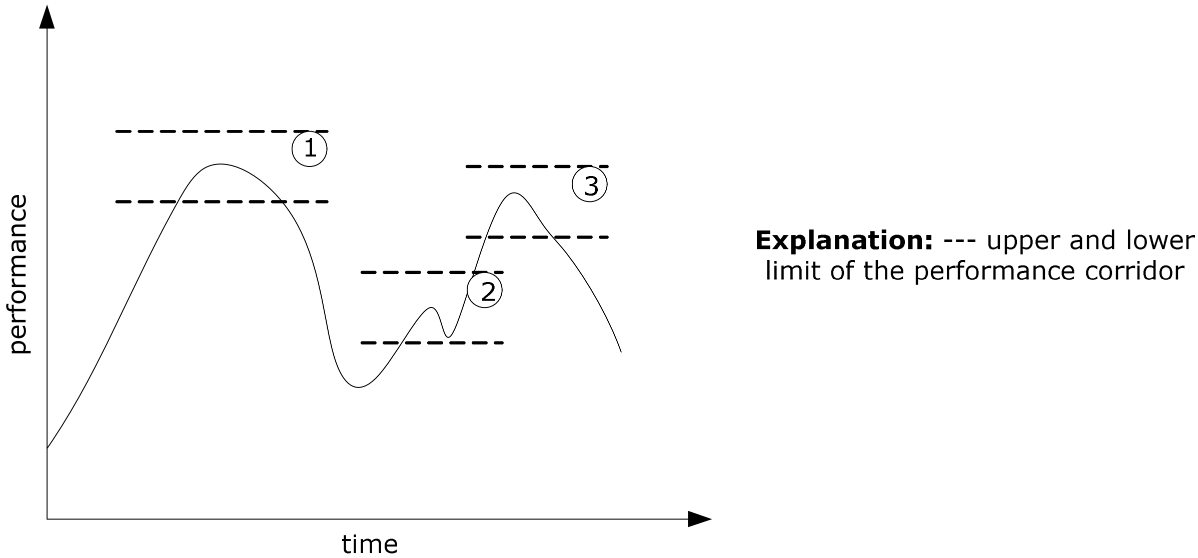


Figure 2: different performance corridors during a time period [16]

The chosen compensation measures have to be verified with the utilization-based simulation tool. Due to this verification, the compensation measures have to be parameterized in the simulation model and a simulation run has to be started. Aftrewards must be checked with the help of the simulation results whether the new demands are fulfilled. If the compensation measures can solve the given problem, the measures have to be implemented in the intralogistics system. Failing this, new measures have to be defeined and verified with the utilization-based simulation.

Herewith the basic function of the utilization-based simulation of the ACP is described. For further information please check the proceedings of the 15th ISL conference in Kuala Lumpur [17].

EVALUATION OF RESOURCE AND ENERGY EFFICIENCY OF INTRALOGISTICS SYSTEMS

Approach and concept

Market-induced effects for an intralogistics system often result from the network (supply chain) or location layer (single enterprise). These effects influence the future utilization and the wear and tear as well as the efficiency of an intralogistics system. Due to this context, it is necessary to analyse the impact of the components of an intralogistics systems for a whole intralogistics system (figure 3)

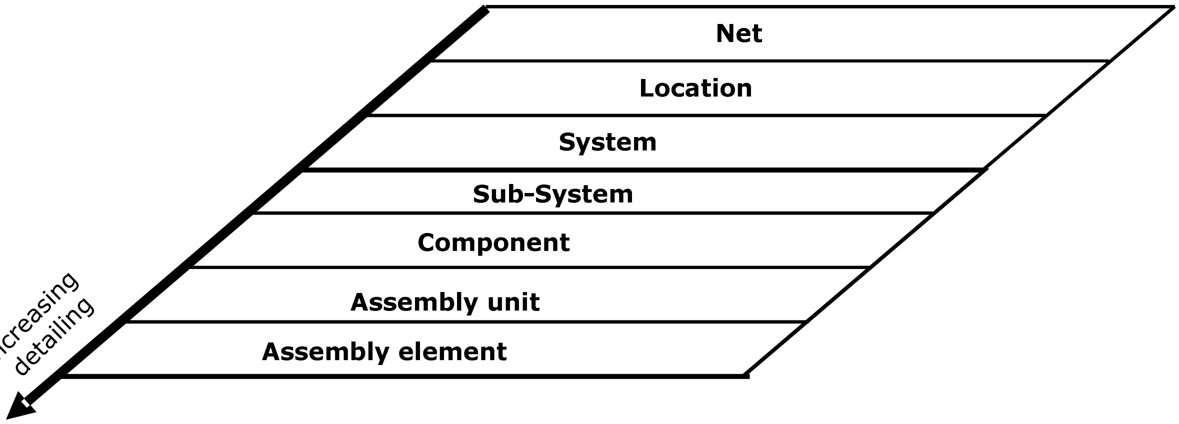


Figure 3: enlargement of the layer for analyzing intralogistics systems

After the interdependence is known between the single intralogistics components, is to be analyzed from which assembly units and elements these are built up. This analysis is necessary to make statements about the efficiency of the components of an intralogistics system. It is also necessary to analyse all the layers, shown in figure 3. These layers represent the basis for an adequate statement about the efficiency of the whole intralogistics system.

To support these analyses of intralogistics systems, tools for visualization and evaluation are required. These tools have to fulfil the following requirements:

- visualization of key performance indicators (KPI)
- integration into the IT-environment
- integration of different condition monitoring technologies (CMT)
- integration of a utilization-based simulation for ACP
- usability for operators.

The future task is to develop a visualization and evaluation tool with the main functions of checking, planning and acting (figure 4). Regarding to the evaluation of the efficiency of intralogistics systems and their components, checking is the essential function of this tool. According to the definition in chapter 'Efficiency', checking of the degree of utilization and wear and tear of the components is necessary, which are resulting from the current and future system load of an intralogistics system. Thus it is possible for the first time to demonstrate the interdependence between utilization and wear and tear of intralogistics systems.

For analyzing the current and future system load of intralogistics systems and its components, the utilization-based simulation for ACP is quite suitable. This concept and its accompanying tool box make the checking of the dynamics of the system load and the resulting impact on an intralogistics system possible. After the check with the utilization-based simulation tool it is possible to decide, whether the system can fulfil the requirement of the future system load. If this is not the case, the tool box supports the search for one or a bundle of compensation measures. These measures can have an operative, tactical and/or strategic character.

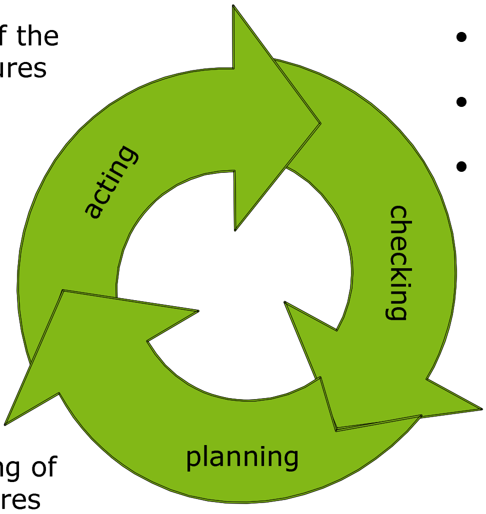


Figure 4: function of a visualization and evaluation tool for resource and energy efficiency

The wear and tear of an intralogistics system can be determined with different Condition Monitoring Technologies as well as by data, gathered from ERP Systems or WMS. Based on documented data (e.g. operating time, downtime, planned maintenance measures) other data like the residual lifetime or degree of wear and tear of intralogistics components can be deduced. Automatic data acquisition is essential for realizing a KPI system. With such a system it is possible to compare KPIs and develop suggestions for adapting an intralogistics system. The results of a permanent as-is and to-be comparison of the KPIs as well as their visualisation and evaluation can be simplified by a tool. The visualisation of the need of change, the condition and / or suggestions for adaption of the intralogistics system by this tool can be supported using traffic light logic (red: danger; yellow: adjustments are necessary; green: no danger). The visualisation of the identified potentials allows proactive planning processes for the identification and implementation adequate measures (or countermeasures). These measures depend on the additional operating time (depending on future utilization and condition of current wear and tear) of the intralogistics systems and its components. The results of the planning processes are operative, tactical or strategic measures for the optimization of the efficiency of intralogistics systems.

Example of energy efficiency of intralogistics systems

An example of an intralogistics system is shown in figure 5a. The illustrated Logistics Condition Monitoring-Technologies Laboratory was established by the chair of factory organisation in cooperation with the Fraunhofer-Institute for Material Flow and Logistics (IML) to analyze the interdependences between utilization and wear and tear of intralogistics systems using condition monitoring technologies (e.g., infrared thermography, vibration analysis, torque or current consumption measurement etc.). This intralogistics system comprises the following sub-systems:

- roller conveyor system
- automated storage and retrieval system (AS/RS – Multishuttle)
- automated guided vehicle system.

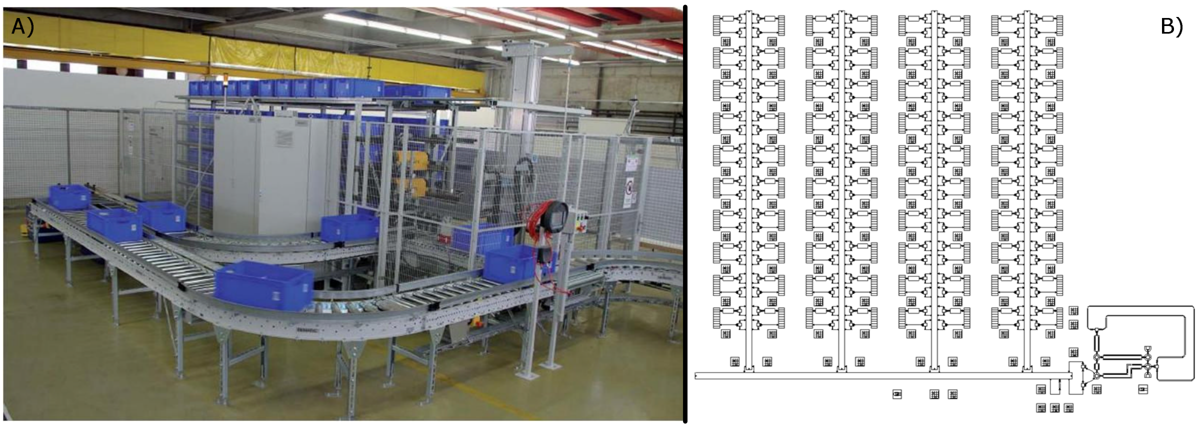
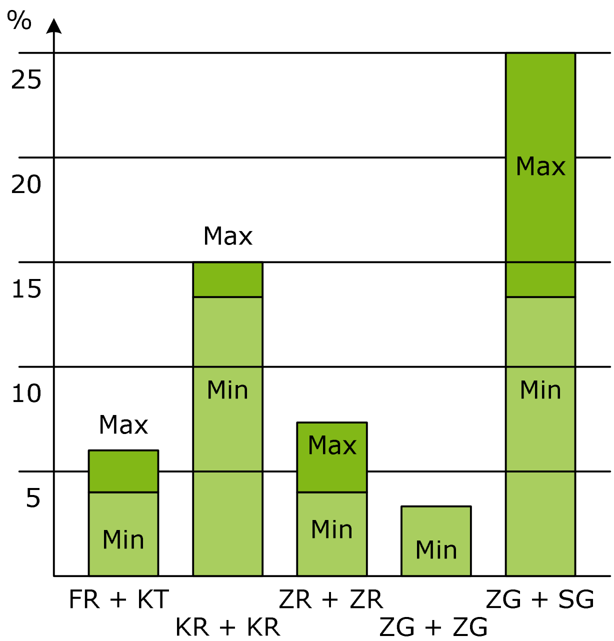


Figure 5a) Log CoMo-Tech Lab; b) utilization-based simulation model [cf. 15]

The roller conveyor system consists of several electric driven roller conveyor components. For the actuator of roller conveyor components different gear designs are used in practice. According to the kind of power transmission there appears to be a transfer loss within an actuator (figure 6).



Achievement of a speed of about 40 1 / min with a 4-pole impulse engine, untersettlement i=35

explanation of the gear combinations:
FR: flat belt; KT: Chain; KR: Fan belts;
ZR: thooth belt; ZG: spur wheel; SG: Snail

Figure 6: transfer losses of different gear designs [cf. 13]

On the condition that in every actuator transfer losses appear, a huge saving potential exists. For the estimation of the possible savings the interdependence between utilization and wear and tear must be known.
The utilization degree of an intralogistics system can be examined with a discrete event-orientated material flow simulation tool. Starting point is a simulation model which allows an utilization-based simulation for Anticipatory Change Planning (cf. figure 5b). With the simulation model different profiles of utilization can be examined and later implemented in the real intralogistics system.
The wear and tear by the different utilization profiles can be taken into account, for example with an infrared camera. The camera allows to determine a change of temperature within the actuator due to different utilization profiles. A deviation between the measured temperature and the nominal temperature means an energy loss. Besides, the temperature is also an indicator for possible damages of the actuator.

The potentials for energy efficiency and / or the oversizing of actuators can be derived from the combined results of the utilization-based simulation and infrared camera with a comprehensive evaluation and visualization tool. Regarding to future demands, measures can be selected and implemented proactively to ensure an optimization of the energy consumption of the actuator of roller conveyors.

CONCLUSION

The ACP is an appropriate simulation-based concept, which ensures a reliable, effective, and efficient operation of intralogistics systems in a continuously changing and dynamic business environment. It allows to check possible system adaptations for solving capacity problems as well as to achieve an optimum implementation of the selected solution.

An utilization-based simulation for an Anticipatory Change Planning represents a basis for the evaluation of resources and energy efficiency. When evaluating the efficiency it has to be taken into account that intralogistics systems or its components are often oversized. As a logical consequence a necessity exists to consider the wear and tear of intralogistics components (as an example). This example makes it additionally clear that the system load is not represented only by the throughput of an intralogistics system, especially the degree of utilization and wear and tear of a system and its components have to be taken into account. This will determine the future research regarding Anticipatory Change Planning. The following topics describe the future research activities:

- extension of the utilization-based simulation tool for Anticipatory Change Planning
- development of an identification number system for the evaluation of efficiency
- integration of the toolbox in the IT infrastructure of an enterprise
- development of a visualization tool
- development of an utilization concept
- adaptation of the measure selection model
- development of a "catalogue of measures" for increasing efficiency

Only if these topics are researched, there is a chance to reach resource and energy efficiency of intralogistics systems.

REFERENCES

[1] Bandow, G.; Wenzel, S. D.; Köpcke, C. (2010): Reliability of Intralogistics-Systems - Oversizing or Maintenance, in: Proceedings of the 4th CIRP International Conference on Competitive Manufacturing, 03.-05.02.2010, Stellenbosch, Südafrika.

[2] Dullinger, K.-H. (2000): Logistik Leitfaden für die Praxis, Mönchengladbach.

[3] Lange, E. (2009): Jungbrunnen für Lagertechnik, in: VDI-Nachrichten 15/2009.

[4] Vahldieck, R.: Stetig sinkende Kosten als Ziel; In: Connect 03/2009, S.10.

[5] Bandow, G.; Kohlmann, B.; Wenzel, S. D. (2008): Robustheit und Modernisierung - ein Widerspruch? Auslegung von Intralogistiksystemen. In: Modernisierungsfibel 2008 "Retrofit & Co."

[6] Kuhn, A.; Bandow, G.; Kohlmann, B.; Wenzel, S. (2008): Zuverlässigkeit von Intralogistiksystemen - Überdimensionierung vs. nutzungsabhängige Instandhaltung. Tagungsband zum 7. Akida, Aachen, 18. bis 19. November 2008, S. 269-276.

[7] Figgener, O. (2006): Standards für die Intralogistik, in: Software in der Logistik - Marktspiegel – Anforderungen, Funktionalitäten und Anbieter in den Bereichen WMS, ERP, TMS uns SCM, München.

[8] Beller, M.(2010): Entwicklung eines prozessorientierten Vorgehensmodells zur Fabrikplanung. Dissertation, TU Dortmund.

[9] Wiendahl, H. P. (1997): Fertigungsregelung - Logistische Beherrschung von Fertigungsabläufen auf Basis des Trichtermodells; Hanser Verlag, München.

[10] Arnold, D. (2006): Intralogistik - Potentiale, Perspektiven, Prognosen, Berlin Heidelberg.

[11] Bernhard, J.; Hömberg, K.; Nagel, L.; Riha, I.; Schürmann, C.; Sieke, H.; Völker, M. (2007): Standardisierte Methoden zur Systemlastbeschreibung, in: Technical Report 07003 – SFB 559 „ Modellierung großer Netze in der Logistik", Dortmund.
[12] Müller, E.; Engelmann, J.; Löffel, T., Strauch, J. (2009): Energieeffiziente Fabriken planen und betreiben, Springer Berlin Heidelberg.
[13] DENA - Deutsche Energie-Agentur (2011): Ratgeber Fördertechnik für Industrie und Gewerbe. URL: http://www.webcitation.org/5xUIpGJ55. Abgerufen am 27.03.2011.
[14] Kuhn, A.; Bandow, G.; Uygun, Y.; Wötzel, A. (2009): Grundmethodik der Antizipativen Veränderungsplanung intralogistischer Systeme - Eine theoretische Analyse, in: Zeitschrift für wirtschaftlichen Fabrikbetrieb, 3/2009.
[15] Uygun, Y.; Luft, N. (2010): Vorgehensmodell zur Maßnahmenselektion: Das Maßnahmenfilter-Modell, in: Bandow, G.; Holzmüller, H. H. (Hrsg.): Das ist gar kein Modell - Unterschiedliche Modelle und Modellierungen in Betriebswirtschaftslehre und Ingenieurwissenschaften, Wiesbaden.
[16] Wötzel, A.; Bandow, G.; Epping, D.: Changeability by Anticipatory Change Planning - Increasing of the changeability for intralogistics systems and production systems. In: Proceedings of 6th International Congress on Logistics and SCM Systems - Sustainable logistics and SCM Systems in resilient market, 07.-09.03.2011, Kaohsiung, Taiwan, S. 238-246.
[17] Wötzel, A.; Kuhn, A. (2010): Utilization-based Simulation for Anticipatory Change Planning. In: Proceedings of the 15th International Symposium on Logistics: Configuring Next Generation Supply Chains, p. 281 - 290.

DECARBONISATION INITIATIVES APPLIED WITHIN THE GERMAN LOGISTICS SECTOR

Jens Tacken[a], Vasco Sanchez Rodrigues[a], Robert Mason[a]
[a] University of Plymouth Shipping and Logistics Unit
[c] Cardiff University Logistics and Operations Management Unit

ABSTRACT
McKinnon (2007) has developed a framework for guiding CO_2 emissions reduction in road freight transport at an aggregated level. However, how road freight transport operations reduce their carbon footprint at a micro level has not been thoroughly assessed. The aim of the paper is to qualitatively evaluate the application transport-related CO_2 reduction initiatives in the German logistics sector. A model based on the McKinnon (2007) CO_2 parameters and CO_2 reduction initiatives linked to these parameters have been developed to frame the research. A multiple case-study approach with ten small cases based on interviews has been applied to address the research aim. The companies studied apply all the existent initiatives recommended for decarbonising road freight transport networks. The investigated firms understand that logistics and ecology do not contradict each other and both need to be considered in their companies' long-term planning. The findings show that measures among the companies fit mainly together. The heterogeneous group of companies shows, in reference to Hervani et al. (2005), that different evolutionary stages in environmental management are available. Larger firms tend to be more developed; nevertheless, CO_2 reduction best practices can be found among medium-sized companies as well.

INTRODUCTION

Over the last two decades, environmental protection has gained increasing significance. Companies are under pressure to reduce the environmental impacts of their logistics operations (McKinnon, 2010). It is estimated that the energy consumed by road freight movement will outpace the energy generated for cars and public transport by 2020s (World Business Council for Sustainable Development, 2004).

McKinnon (2007) has developed a framework for guiding CO_2 emissions reduction in road freight transport at an aggregated level. However, how road freight transport operations reduce their carbon footprint at a micro level has not been thoroughly assessed. The aim of the paper is to qualitatively evaluate the application transport-related CO2e reduction initiatives in the German logistics sector. 'Green logistics encompasses all measures applied to optimize of vehicle utilization, consolidate and optimize of tours to reduce traffic and traffic-related emissions, reduce traffic-related and stationary environmental impact of logistics' (Lohre and Herschlein, 2010). This definition will be used to frame the research.

DECARBONISATION INITIATIVES APPLIED TO ROAD FREIGHT TRANSPORT

In the literature, the CO2 reduction measures have been identified over the years. Measures were identified early by Wu and Dunn (1995) and extended over the years by e.g. Wee et al. (2005) and McKinnon (2008, 2007). Moreover, authors have specialised their discussions on technical components to increase efficiency (Shell Deutschland Oil GmbH, 2010), modal shift (Wee et al. 2005, Woodburn and Whiteing, 2010) or the routing optimization (Eglese and Black, 2010). Consolidating much of this work up to 2007, McKinnon (2007) developed seven ratios for guiding CO2e emissions reduction in road freight transport and further identified seven key parameters and corresponding determinants to map the relationships between logistics activities and related environmental costs.

In this paper, the CO2e emissions reduction parameters proposed by McKinnon (2007) have been linked with carbon reduction initiatives recommended in the literature. Twelve recent articles from the fields of freight transportation and environment and/or GSCM have been consulted to identify potential measures and activities to reduce CO2e emissions of road freight transport. The articles selected are: [1] Arbeitskreis Nachhaltigkeit des Logistik-Initiative Hamburg e.V. (2010), [2] Eglese and Black (2010), [3] Shell Deutschland Oil GmbH (2010), [4] Woodburn and Whiteing (2010), [5] McKinnon (2008), [6] Heriot-Watt University (2007), [7] McKinnon (2007), [8] Preuss (2005), [9] Wee *et al.* (2005), [10] Hoogma *et al.* (2002), [11] Boege (1995), [12] Wu and Dunn (1995),.The identified initiatives to reduce CO2e emissions in road freight transport are assigned to the parameters of the green logistics framework (Table 7, next page) and matched against strategic (S), tactical (T) or operational (O) decision levels (Simchi-Levi et al., 2008).

Parameter	**Initiative**	**Authors**	**Decision-making level**
Modal split	Modal shift	[1], [4], [5], [7], [9], [11], [12]	Tactical/Operational
Average handling factor	Network optimisation	[5], [6], [7], [11], [12]	Strategic
Average length of haul	Network optimisation	[5], [6], [7], [11], [12]	Strategic
	Vehicle routing optimisation	[1], [2], [5], [6], [7], [8], [9], [10], [12]	Operational
Vehicle utilisation (Average load on ladden trips and average empty runnings)	Consolidation	[1], [5], [6], [7], [8], [9], [12]	Operational
	Increase backhaulage	[1], [2], [5], [6], [8], [9], [12]	Operational
	Increase vehicle dimensions	[1], [5], [6], [7], [12]	Strategic
Vehicle fuel efficiency	Driver training	[1], [3], [5], [6], [7], [9]	Tactical/Operational
	Driver incentive schemes	[1], [5], [6], [7]	Tactical
	Fuel efficient vehicle engines	[1], [5], [7], [8], [9], [11]	Strategic/Tactical
	Reduce power rating	[7]	Tactical/Operational
	Reduce vehicle tare weight	[3], [5], [6], [7], [9]	Strategic/Tactical
	Aerodynamics profiling of trailer and tractor	[1], [3], [5], [6], [7], [9]	Strategic/Tactical
	Improve tyre performance	[1], [3], [5], [6], [9]	Strategic/Tactical
	Effective vehicle maintenance	[1], [5], [7], [9], [12]	Tactical/Operational
	Fleet management (scheduling)	[1], [2], [3], [5], [7], [8], [9], [12]	Operational
Carbon intensity of fuel used	Alternative and less carbon intensive energy sources	[1], [3], [4], [5], [6], [7], [9], [10], [11], [12]	Strategic/Tactical

Table 1: Evidence of CO2e emissions reduction initiatives for German road freight transport (framework adapted from McKinnon, 2007)

THE GERMAN LOGISTICS SECTOR

There are 1,251 active companies undertaking business in logistics-related areas in Germany (Bundesamt für Güterverkehr, 2010). The sector turnover was euro 190 billion in 2007, which was 5% up on 2006. It is thus recognised as a strong growth sector in the German economy (Deutsche Bank Research, 2008). The logistics market is dominated by small and medium-sized enterprises (SMEs) (Bundesamt für Güterverkehr, 2010). However, large national and international acting logistics companies are becoming increasingly prevalent (Deutsche Bank Research, 2008).

Although the sector has since 2007 suffered under the economic downturn following the global banking crisis of 2007/2008 (Bundesamt für Güterverkehr, 2010), it is worthwhile mentioning that the environment is still on the agenda of the sector (AMMPL and

Wittenbrink, 2009). Road freight transport is the most important mode in Germany (Deutsche Bank Research, 2008) and has maintained this primary role in comparison to the other modes (Eurostat, 2010; European Environment Agency, 2009) for many years. As a result of this dominance the sector accounts for 78% of the total emissions from freight transport in Germany. However, it has managed to decrease its CO2e emissions by 5% in total from 1990 till 2007 (International Transport Forum, 2010).

METHOD

The research follows a deductive-to-inductive approach using deduction as foundation and induction to identify new insights. The researcher decided to apply a multiple case-study approach with ten small cases based on interviews to address the research aim. Case study research has recently been discussed within logistics (Aastrup and Halldorsson, 2008; Seuring, 2008). This approach provides flexibility in the data collection and triangulation can be also be applied to increase the research quality (Saunders *et al.*, 2009; Locke *et al.*, 2000).

As recommended by Maylor and Blackmon, 2005, a non-probabilistic purposive sampling strategy was applied to select the case studies. Hair et al. (2007) point out that convenience, speed and low cost are the main advantages of purposive sampling. The approach of heterogeneous sampling was also applied to select the case studies, as suggested by Saunders *et al.* (2009), considering two main company characteristics: number of employees and sectors served. Different sources were used to identify the companies: the German Logistics Association (BVL), transport markets (e.g. www.logismarket.de) and homepages of logistics magazines (e.g. www.verkehrsrundschau.de). An invitation, together with the study proposal, was sent to 30 companies. Five of these companies responded positively to the invitation. Subsequently, 20 other companies were contacted and five additional companies accepted to participate. During the follow-up process, the Frohlich's (2002) recommendations to increase the response rate were applied: 'pre-notice', 'appeals', 'results' and 'steady pressure'.

As Table 2 shows, the sample studied presents diverse characteristics, notably in terms of company size (number of employees). The companies offer a wide range of logistics services in several sectors and have international logistics coverage. Nevertheless, company E offer full logistics services nationally and internationally but specialised on the chemical sector. All the interviewees, with the exception of the one from company I, influence the decision making of national as well as international transport flows.

During the case studies, managers from the logistics providers investigated were interviewed. The interviews lasted between 60 and 90 minutes and were semi-structured in nature. In semi-structured interviews, the researcher prepared an interview-guideline (following Saunders et al., 2007). The first part of the interviews was introductory (topic, course of action, recording permission and confidentiality) and contained general questions regarding the interviewee and company. Part two, the core part, was focused on the aim of the study. The third part, the closing part, rounded the interview off.

In addition, following Oppenheim's (1992) recommendations regarding how to reduce bias in the application of interviews, the researcher was open-minded in the opening, asked questions in the same tone, using the same non-verbal signals, and so on. The initial invitation also emphasized that the identities of companies were to be kept confidential and informed partcipants about the nature of the investigation and their role within the study (Locke et al., 2000). The interviews were tape-recorded and typed in German and translated into English. Subsequently, the interview scripts were synthesized by applying content-analysis, as recommended by Saunders et al. (2007), into an Excel table. Keynotes were returned for final adjustment and approval by the interviewee. The data was analyzed using cross-case analysis, as suggested by Maylor and Blackmon (2005).

Company	Employees (Germany)	Locations	Department of Interviewee	Interview	Logistics Services	Client Sector(s)	Decision-Making Domain of Interviewee
A	400	Germany	Management Board	Face-to-face	Full logistics services:	Various sectors of industry and trade	National and international flows
B	400	Europe	Quality & Environmental Management	Telephone	Transportation, warehousing, contract logistics and special services	Chemical, consumer goods, metal, paper	National and international flows
C	500	Germany	Controlling	Face-to-face	Transportation, warehousing, value adding logistics, contract logistics and special services	Bulk / silo products: chemical sector, food sector	National and international flows
D	800	Europe	Quality Management	Face-to-face	Full logistics services	Automotive, chemical, electronics	National and international flows
E	1000	Germany	Controlling / Project Management	Telephone	Full logistics services	Chemical sector	National and international flows
F	1500	Global	Project Management	Telephone	Transportation, value adding logistics, contract logistics and special services	Automotive sector, financial sector, insurance sector, public sector	n/a
G	1700	Europe	Project Management	Face-to-face	Full logistics services	Various sectors of industry and trade	National and international flows
H	3500	Global	Quality & Environmental Management	Telephone	Full logistics services	Automotive, consumer goods, fashion, electronics, food	National and international flows
I	4000	Global	Environmental Management	Telephone	Full logistics services	Automotive, food, clothing	National flows
J	10000	Global	Project Management	Telephone	Full logistics services	Automotive,, electronics, chemical, pharmaceutical, metal	National and international flows

Table 2: Characteristics of the participating logistics providers

IMPLEMENTATION OF CO2e EMISSIONS REDUCTION INITIATIVES IN GERMAN ROAD FREIGHT TRANSPORT

The CO2e emissions reduction initiatives shown in Table 1, developed from McKinnon's (2007) CO2e emission ratios, are used as a basis for the analysis. The initiatives gathered in the interviews are shown in Table 3.

There appeared to be a consensus of view among participants about modal split. All companies attempted to transfer loads to the less environmentally harmful modes (mainly rail, also barge); nevertheless they emphasised that this depends mainly on their customers' requirements. Company D would use those modes more frequently if adequate infrastructure was available.

Regarding the average handling factor, the application of network optimisation in hub facilities seemed to be reserved to larger firms (Companies G and J). However, in the case of length of haul, vehicle routing improvement was widely used (Companies A, B, C, D, E, F, G, H and I). According to the participants from companies A, B, E, F, G, H, and I, their firms had ICT tools for solving vehicle routing and scheduling problems, and companies C and D planned the implementation of them, as suggested by Eglese and Black (2010).

Initiatives	A	B	C	D	E	F	G	H	I	J
Modal shift to rail	No possible	Driven by customers	Driven by customers	Driven by customers	Driven by customers	Driven by customers	1	Driven by customers	Driven by customers	Driven by customers
Modal shift to water				1						
Network optimisation				1			1	1	1	1
Vehicle routing optimisation	1	1	1	1	1	1		1	1	
IT vehicle routing		1	1	1		1	1	1	1	1
Volume consolidation		Difficult	Difficult		1		1	1	1	1
Increase back haulage	1				1	1			1	
Increase vehicle dimensions	1					1				1
Inter-company collaboration							Yes, with customers	Yes, with customers	Yes, with other carriers	Yes, with customers
Driver training		1	1	1	1	1	1	1	1	Yes, including subcontractors' drivers
Driver incentive schemes			1				1	1		
On-board computers to measure fuel consumption							1			
Fuel efficient vehicles	Euro 4 and 5	Euro 5, but difficult in subcontractors	Euro 5	Euro 5, but Euro 6 not approved	Euro 4	Yes, but not specified		Euro 5	Euro 5 and 6	Euro 5
Reduce power-rating										
Reduce vehicle tare weight										
Vehicle aerodynamics									Only in tractors	
Improve tyre performance				1				1		
Vehicle maintenance	1	1								
Fleet management and scheduling		1	1	1						
Telematics for scheduling	1		1			1	1	1	1	1
Alternative fuels/energy sources	No		1	Biodiesel not approved after tested	No	Biodiesel not approved after tested	Biodiesel not approved after tested	Biodiesel not approved after tested	AdBlue is used	Second generation of biodiesel

Table 3: CO2e emissions reduction initiatives found in German road freight companies surveyed

Vehicle utilisation was significantly supported by the interviewees. Consolidation of goods was, with the exceptions of companies B and C, undertaken by all logistics providers studied. This was also the case for the application of backhaulage to reduce of empty running. However, there was a fair degree of difference noted from the sample studied regarding the measures of increasing vehicle dimension and inter-company collaboration. Extensions in vehicle dimensions seemed to be reserved to the larger companies, but the medium-sized company A is an exception to this rule. Several participants mentioned they use double-decker, jumbo and longer and heavier vehicles trailers (Companies A, F, H, I and J). Inter-company collaboration was pursued in different ways by the companies, e.g. logistics alliances (Companies D, G and I), within the own corporate groups (Companies I and J) or focused collaboration with customers (Company H, I and J).

A wide range of evidence was found regarding improvements on vehicle fuel efficiency. All interviewees supported driver training as a means of reducing vehicle fuel consumption. Different approaches of driver training were available which ranged from an own driving instructor in the medium-sized companies to large programmes for own and external (subcontractors) drivers among the larger one. Driver incentives schemes were mentioned by practitioners from companies C and H, and also company G planned to implement them. The interviewee from company D said that they also instruct transport planners. Strong evidence was also found among the participating companies regarding the usage of fuel efficient engines. The companies' fleets complied with Euro 4/5 emission standards, and also subcontractors' vehicles in the case of companies B, H, I and J.

Limited support among participants was found to be given to other measures to improve vehicle fuel efficiency, e.g. the reduction of power rating and vehicle tare weight, and improved maintenance activities, are only mentioned by the interviewee from company F. In contrast, as recommended by Shell Deutschland Oil GmbH (2010), low-rolling-resistance tyres (Companies A, D, H and J) and the application of acronymic features (e.g. side covering) (Companies A, I and J) was evident. Furthermore, those aerodynamic measures seemed to be vulnerable to becoming unfeasible due to the continuous changes in tractors and trailers (Company I). Regarding the ratio of 'fuel carbon intensity', many of the companies studied tested the usage of alternative energy sources. Biodiesel was piloted by companies C, D, F, H and I with negative results, since damage in the vehicles engines was caused by biodiesels. The ethical discussion about the topic of biodiesel induced companies to stop using them (Company A, C, D, F, H, I and J). Companies H and J also considered second generation of bio-fuels as well as hybrid motorisation in company I and J. Also, companies C and I use AdBlue, a 32.5% solution of high-purity urea, to fulfil the Euro 4 and 5 emission standards.

Finally, representatives from companies A, G and J said that not all measures can be implemented, since feasibility studies required to be undertaken before implementing any initiatives (Company C). However, the application of cost-benefit analysis is difficult, because the effectiveness of any environmental solution needed to be assessed among all their life-span (Company A). The companies investigated applied operational to tactical decisions (e.g. routing optimisation or consolidation) whereas tactical to strategic measures were infrequent. As McKinnon (2010) stated, unsuitable decisions taken at higher levels could vaporise gains achieved at operational levels.

MANAGERIAL IMPLICATIONS

The analysis of the green logistics initiatives shows strong evidence that the options identified in theory are also valid for the German companies investigated. However, it seems to be difficult to distinguish between ecological-related and economic-related measures. High support among the companies was identified for modal shift, the optimisation of vehicle routing and scheduling, increase of vehicle utilisation, driver training and a fuel efficient fleet. Furthermore, according to the participants, alternative fuels were tested in their companies, but only with little penetrating power. Certain relevance also belongs to the application of collaboration which was identified. Most of the participating companies apply operational options to reduce the environmental impact, tactical and strategic actions seem to be taken individually.

Only occasional differences between medium-sized and large companies were found mainly for strategic decisions which could be explained by the available network and the financial capabilities. However, this would need further investigation and evidence. Moreover, the green logistics framework by McKinnon (2008, 2007) seems to be fully applicable for the sample studied. No further categories were required. German third party logistics need to find an inter-organisational agreement on the definition of green logistics, its range and standards to allow benchmarking. With regard to decarbonisation initiatives, simulation of different scenarios considering trade-offs at different decision levels are advised and attention should be focused at establishing clear distinction between ecological- and economic-related activities.

CONCLUDING REMARKS

The model developed by linking McKinnon's decarbonisation framework and other relevant literature works have been confirmed in the study. The companies studied apply all the existent initiatives recommended for decarbonising road freight transport networks. The strong agreement with the theory restricts the inductive elements to enhance the theoretical basis on the present investigation. The investigated firms understand that logistics and ecology do not contradict each other and both need to be considered in their companies' long-term planning. The findings show that measures among the companies fit mainly together. The heterogeneous group of companies shows, in reference to Hervani et al. (2005), that different evolutionary stages in environmental management are available. Larger firms tend to be more developed; nevertheless, green best practices can be found among medium-sized companies as well.

The research was limited in terms of funds. A bigger sample could have been investigated as well as triangulating the findings from the case studies with a survey. The findings of this study are the starting point for three directions of suggested further research. The first one could aim to investigate the present restrictions and selection criteria on a wider research perspective, taking into account more companies to allow generalisation. The second could use the same settings; however, transfer it to different logistics services or a different modality. The third could be undertaken witha slightly narrower focus on customer contractual arrangements and type of commodity transported, to be investigated in more detail.

REFERENCES

Aastrup, J., Halldorsson, A. (2008) Epistemological role of case studies in logistics: a critical realist perspective. International Journal of Physical Distribution & Logistics Management. 38 (10), 746-763.

AMMPL & WITTENBRINK, P. (2009) Green-Logistics – hohe Bedeutung auch in Krisenzeiten [online]. Frankfurt/Loerrach: Association Materials Management Purchasing and Logistics. Available from: http://www.bme.de/fileadmin/bilder/PDF/AuswertungGreenLog.pdf [Accessed 10th February 2010].

Arbeitskreis Nachhaltigkeit Des Logistik-Initiative Hamburg E.V. (2010) Leitfaden Nachhaltigkeit in der Logistik: Anforderungen, Umsetzung in die Praxis, Beispiele. Hamburg: Logistik-Initiative Hamburg Service GmbH.

Bundesamt Für Güterverkehr. (2010) Struktur der Unternehmen des gewerblichen Güterkraftverkehrs und des Werkverkehrs. Köln: BAG.

Deutsche Bank Research. (2008) Logistik in Deutschland: Wachstumsbranche in turbulenten Zeiten. Frankfurt am Main: Deutsche Bank Research.

Eglese, R. & Black, D. (2010) Optimizing the routing of vehicles. In: MCKINNON, A. C., European Environment Agency. (2009) Transport at a crossroads. TERM 2008: indicators tracking transport and environment in the European Union. Luxembourg: Office for Official Publications of the European Communities.

Frohlich, M. T. (2002) Techniques for improving response rates in OM survey research. Journal of Operations Management. 20 (1), 53-62.
Heriot-Watt University (2007) *Transport Management: A Literature Review* [online]. Work Module 1 Green Logistics Project. Edinburgh.
Hervani, A. A., Helms, M. M. & Sarkis, J. (2005) Performance measurement for green supply chain management. Benchmarking: An International Journal. 12 (4), 330-353.
Hoogma, R., Kemp, R., Schot, J. & Truffer, B. (2002) Experimenting for Sustainable Transport: The approach of Strategic Niche Management. London, New York: Spon Press.
International Transport Forum (2010) Reducing Transport Greenhouse Gas Emissions: Trends & Data 2010 [online]. Available from: http://www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdf [Accessed 30th June 2010].
Locke, L. F., Spirduso, W. W. & Silverman, S. J. (2000) Proposals that work: A Guide for Planning Dissertations and Grant Proposals. 4th edn. Thousand Oaks: Sage Publications.
Lohre, D., Herschlein, S. (2010) Grüne Logistik - Studie zu Begriffsverständnis, Bedeutung und Verbreitung „Grüner Logistik" in der Speditions- und Logistikbranche. Bonn: Deutscher Speditions- und Logistikverband e.V. (DSLV).
Maylor, H. & Blackmon, K. L. (2005) Researching Business and Management. Basingstoke: Palgrave Macmillan.
Mckinnon, A. C. (2007) CO2 Emissions from Freight Transport in the UK [online]. Available from: http://cfit.independent.gov.uk/docs/2007/climatechange/pdf/2007climatechange-freight.pdf [Accessed 3rd March 2010].
Mckinnon, A. C. (2008) The Potential of Economic Incentives to Reduce CO2 Emissions from Goods Transport. 1st International Transport Forum on 'Transport and Energy: the Challenge of Climate Change', 28th-30th May 2008, Leipzig.
Mckinnon, A. C. (2010) Environmental sustainability: a new priority for logistics managers. In: MCKINNON, A. C., CULLINANE, S., BROWNE, M. & WHITEING, A. (eds.) Green Logistics - Improving the environmental sustainability of logistics. London: Kogan Page.
OPPENHEIM, A. N. (1992) *Questionnaire Design, Interviewing and Attitude Measurement*. London, Washington: Pinter.
Preuss, L. (2005) The Green Multiplier: A Study of Environmental Protection and the Supply Chain. Basingstoke: Palgrave Macmillan.
Saunders, M., Lewis, P., Thornhill, A. (2009) Research Methods for Business Students. 5th ed. Harlow: Prentice Hall.
Seuring, S. (2008) Assessing the rigor of case study research in supply chain management. Supply Chain Management: An International Journal. 13 (2), 128-137.
Shell Deutschland Oil GMBH. (2010) Shell Lkw-Studie: Fakten, Trends und Perspektiven im Straßengüterverkehr bis 2030. Hamburg/Berlin: Shell Deutschland Oil GmbH.
Woodburn, A., Whiteing, A. (2010) Transferring freight to 'greener' transport modes. In: MCKINNON, A. C., CULLINANE, S., BROWNE, M. & WHITEING, A. (eds.) Green Logistics - Improving the environmental sustainability of logistics. London: Kogan Page.
World Business Council For Sustainable Development & World Resources Institute. (2004) The Greenhouse Gas Protocol: A corporate accounting and reporting standard. Geneva / Washington: World Business Council for Sustainable Development & World Resources Institute.
Wu, H.-J., Dunn, S. C. (1995) Environmentally responsible logistics systems. International Journal of Physical Distribution & Logistics Management. 25 (2), 20-38.

A MERGER BETWEEN QUALITY AND REVERSE LOGISTICS IN THE PHARMACEUTICAL INDUSTRY: A STATE OF THE ART REVIEW

Ana Margarida Santos Bravo[1], *José Crespo de Carvalho*[2]
[1] Researcher in Pharmaceutical Supply Chains - ISCTE –IUL – Lisbon University Institute, Lisbon, Portugal, margarida.bravo@gmail.com
[2] Full Professor, ISCTE –IUL – Lisbon University Institute, Lisbon, Portugal
crespo.carvalho@gmail.com

ABSTRACT
Due to the increase of drug product recalls in the last decade, reverse logistics has amplified its importance in the pharmaceutical industry, as environmental concerns are also one of the hot topics on the business agenda. The aim of this paper is to review the state of the art on drugs quality and safety and merge it with the reverse logistics function in the pharmaceutical industry. The study yielded interesting outcomes such as added value and customer satisfaction, competitive advantage and the resource of outsourcing through the use of third party logistics. It was found that as quickly as the reverse operation occur the happier the customers are, with an increase in profits and responsiveness of the industry.

Keywords: Reverse Logistics, Quality Issues, Pharmaceutical Industry, Globalization

1. INTRODUCTION
World pharmaceutical industry is one of the most R&D intensive and innovation driven industries. However, it has been changing profoundly in the last decade due to the intensive globalization process, increased competitiveness, fast changing structure of competitors, a complex strategic positioning and a fight for global market share, shrinking pipelines, expiring patents, counterfeit drugs, create new challenges for pharmaceutical companies. Therefore, all stages of the business value chain are affected, from development of new drugs to the management of the manufacturing and supply networks (Papageorgiou et al. 2001; Almor 2009, Edwards 2010). Plus, pharmaceutical companies underlie strong regulations dictated by the Food and Drug Administration (FDA) for example; in spite of the industry focus on quality, pharmaceutical manufacturing has failed to keep up with other industries in terms of efficiency and productivity. Even small irregularities in product or process can lead to the elimination of the whole production batches and in the worst case enormous civil penalties (Granauer et al*.* 2009). Industry sources have estimated the total of returns cost to be 3 to 6% of the annual pharmaceutical sales (Hunter et al. 2005). In recent years the number of drug recalls has more than doubled with ranges from 5 to 10% (Abboud and Hensley 2003), in 2009 alone, according to CNN (2010) 1,742 recalls were registered, with an estimated $5 billion dollars (Kumar et al*.* 2009).

Complex requirements are forcing pharmaceutical manufacturers to adopt more formal business processes and stricter reporting methods (Souza et al. 2005); in order to increase value for shareholders, pharmaceutical companies will need to restructure their business from top to bottom (Reuters 2009).

Furthermore, as John Avellanet (2009) suggests 'As long as the industry fails to take a holistic cross-functional view of regulatory compliance, risk management and operational excellence, it will continue to see consent decrease, product recalls and tremendous waste'. Even though, pharmaceutical returns and recalls are not a regular event, companies must react quickly and effectively, to clear the supply chain from non-conforming material (Kumar et al. 2009; Ritchie et al. 2000).

The intent of this paper is to explore the link between pharmaceutical drugs quality and reverse logistics regarding the questions arisen in the beginning of this section, towards the pharmaceutical industry. The rest of the paper is organized as follows: we begin with a discussion on the review methodology, followed by a literature review in pharmaceutical industry quality and reverse logistics. Outcomes of the review are then presented. Finally, concluding remarks, together with managerial implications and future research are summarized.

2. METHODOLOGY REVIEW

We will explore the links between pharmaceutical quality issues and reverse logistics, arisen in the introduction section. In this revision we conducted a significant literature review to better understand and define the situation that the pharmaceutical industry faces when it comes to reverse logistics.

The first step was to define the situation. The introduction gave sufficient facts as the dimension of the situation, with the limited availability of detailed information in pharmaceutical reverse chain; our approach was to review the literature using specific keywords in electronic databases, over 'reverse logistics', 'pharmaceutical quality' and 'recalls'. The search engines used were ProQuest, Science Direct, Emerald Insight, Interscience, Elsevier, Springer and Google Scholar to explore literature. After defining priorities, the next step was to determine whether the reviewed content was appropriate for the outcome of this research. According to Li et al (2008), keyword search is a popular document system query; additionally, content analysis is an observational research method that is used to systematically evaluate the symbolic content of all forms of recorded communication, as stated by Kolbe and Brunete (1991). The referred terms were searched individually in order to find relevant data, latter these same terms were grouped between each other so that we could narrow findings and identify patterns and links.

In this search a total of 98 papers were reviewed, from that only 52 papers were of relevance to this paper, 3 books, related to integrated supply chain and quality, and 35 journal publications have been reviewed. The literature reviewed show that 10 articles were published between 1979-1999, and 42 after 2000. Although the theme is of increasing interest is was noted that very little articles mention reverse logistics in the pharmaceutical industry. Articles were found in areas of marketing management (1), operations management (5), supply chain and reverse logistics management (10), quality and compliance (7) and business management (6). It was also noted that there is a very scattered distribution where the articles were found, not having one single publication with a majority of articles published. It was also included three papers from CNN, Reuters and the Wall Street Journal, as well as technical papers like pharma QbD (Quality by Design) and Pharmaceutical Contract Manufacturing, these type of articles serve the purpose to show the stakeholders concern regarding quality failures in the pharmaceutical industry. In the relevant articles, books, references cited were examined to find out additional sources of information. The outcome of the content analysis is shown in the following sections.

3. PHARMACEUTICAL QUALITY FAILURE

3.1. Background

The pharmaceutical industry as a whole has traditionally been very profitable. On a global scale, the total size of the global pharmaceutical market has been forecasted to experience grow 4-6% exceeding $825 billion. The global pharmaceutical market sale is expected to grow at a 4-7% rate (CAGR) through 2013. Global pharmaceutical market value is expected to expand to $975+ billion by 2013 (IMS Health 2010). Moreover, total pharmaceutical sales from the top 10 companies accounted for more than 4% of the total market. Additionally, the US pharmaceutical market grew by 3.0% in 2009 to $300.3 billion with highest growth in mail services and clinics; the major five Germany, France, Italy Spain and the UK, together accounted for over 60% of all European pharmaceutical sales in 2009 (Pharmaceutical Market Trends, 2010). Conversely, product recalls in the pharmaceutical industry are becoming extensive and increased radically, according to CNN (2010) in 2009 alone, the Food and Drug Administration reported more than 1,742 recalls comparing to 426 from 2008, with an estimated $5 billion dollars and more than $700 million in fines since 2001 and billions more in lost revenues (Kumar et al. 2009, Souza et al. 2007).

3.2. Quality Issues

We shall first start to comprehend the process behind drug products approval. No pharmaceutical product can be placed on the market without receiving prior authorization from the regulatory authorities, upon successful completion of a lengthy procedure for evaluating the quality, safety and efficacy of the product moreover; regulators around the world have become more sophisticated in ensuring that drugs are safe and effective (Levis and Papageorgiou 2004, Souza et al. 2007). The evaluation goes primarily against the drug manufacturing regulations which are based in the FDA good manufacturing practices (GMP), conceptualized in 1941 and formerly introduced in 1970s, for instance in as the late as the 1980s for instance, the primary focus of the FDA was to prevent fraudulent drugs from reaching consumers. By the late 1990s it focused more on the drug makers' processes. Today the FDA has taken a much more system-wide approach to evaluating the quality of pharmaceutical manufacturing plants and networks. These regulations have been improved through a management of system approach, in particular with the harmonization between risk analysis and quality systems. These changes have improved the approach to GMP compliance, marketing compliance more comprehensive, integrated, and focused on areas of the greatest impact (ICH 2011, Pluta and Poska 2010, Souza et al. 2007).

Total quality is described by Feigenbaum and Feigenbaum (1999) as a major factor in the business quality revolution and proved itself to be one of the most powerful creators of soundly based and suitable business expansion and as 'fitness for purpose' (Juran 1988), an interpretation of which could be that changes made within an operation should be made for a reason with positive business outputs, or else quality improvements would not exist (Dale 2003). Nevertheless, in pharmaceuticals, any change that a company wants to make is always going to be subject to the pervasive requirements of safety, efficacy, quality and cost, making some companies to remain locked into an ancient mindset that says that providing outcome meet specifications, all is well (McConnel et al. 2009). However, this type of approach has been demonstrated fallacious, and to be likely to increase deviations and recalls (Mahboubian-Jones 2009).

A recall is the actions taken by a firm to remove a product from the market; a correction is made to the product because it is either defective or potentially harmful. It may be conducted on a firm's own initiative, by FDA request, or by FDA order under statutory authority; on the same line, the EMA defines a batch recall as the action of withdrawing a batch from the distribution chain and users. A batch recall may be partial, in that the batch is only withdrawn from selected distributors or users (EMA 2011; FDA 2011). Comparing the European (EMA, European Medicines Agency) terminology with the United States (FDA, Food and Drug Administration), one can verify that recalls are viewed similarly by both entities. Table 1, highlights the parallels between the types of recall classification by the two organizations

	FDA	**EMA**
Class I recall	A situation in which there is a reasonable probability that the use of or exposure to a violative product will cause serious adverse consequences or death	The defect presents a life threatening or serious risk to health
Class II recall	A situation in which use of or exposure to a violative product may cause temporary or medically reversible adverse health consequences or where the probability of serious adverse consequences is remote	The defect may cause mistreating or harm to the patient or animal, but is not life threatening or serious
Class II recall	A situation in which use of or exposure to a violative product is not likely to cause adverse health consequences	The defect is unlikely to cause harm to the patient, and the recall is carried out for other reasons, such as non-compliance with the market authorization or specification

Source: FDA and EMA (2011)

Table 1 – Recall classification comparison

The decision to recall a product may be due to the following reasons: the quality of product not conforming to the registered specification during its shelf life; the packaging being found to lead to deterioration within its declared shelf life; statements made on a label or leaflet not being in accordance with the requirements as registered; adverse reactions occurring, unsuitability or being hazardous to the user; and the product being suspected to be counterfeit or tampered with; similarly as per FDA, a product is recalled due to comprise issues related mix-ups, volume, potency, tampering, quality of dosage forms, questioned generic substitutions, labeling defects, lacking therapeutic effects, question formulations, dispenser malfunction and container defects (Cheah et al. 2007, EMA 2011, FDA 2011,). Table 2 identifies and compares the most common incidents registered by both FDA and EMA for the 2005 period.

CDER		**EMA**	
Category	**Incidence (%)**	**Category**	**Incidence (%)**
Product Defects	27%	Product defects	15%
Formulation/ Substitution	24%	Deviation from Manufacturing Authorization	15%
Labeling	13%	Product information literature	23%
Packaging	6%	Packaging material	14%
Fill Problem	5%	Ancillary materials	14%
Delivery	13%	OOS	12%
Other	12%	GMP findings	7%

Source: CDER (FDA), 2007 & EMA, 2007

Table 2 - Reported Drug Quality Defects

To sum up, expectations on safety and health are increasingly, more and more due to globalization. Firms in the pharmaceutical industry are now expected to be responsible to economic, societal and environmental needs. Moreover; environmental protection and sustainability cannot only be used to improve the public perception of the manufacturing efficiency as costs for input and output resources (Stegemann 2010). Therefore, product recalls could damage a company's revenues, reputation, profitability, publicity and brand integrity (Yaros and Wood 1979), beyond being a costly exercise to a firm as replacing recalled product or paying for damages caused in use, as usually required. Also product recalls are generally viewed unfavorably by investors, and a failure to their systems quality (Cheah et al. 2007, Krumwiede et al. 2002).

4. REVERSE LOGISTICS & PHARMACEUTICAL RECALLS

4.1. Background

It is generally accepted that organizations need to maintain traceability of their products throughout the supply chain in order to instigate retrieval (product recalls) and to ensure efficient use and recycling of distributed stock. Such activities fall under the general heading of supply chain management. As with all supply chain activities, logistics is concerned with cost containment and reduction. Nevertheless, as discussed by Bowerox and Closs (1996) the real importance of logistics is its ability to give organizations a competitive advantage by providing customers with superior service through inventory availability, and speed and consistency of delivery. Yet, the opposite may be required, not totally a symmetrical image (de la Fuente 2010), reverse logistics is an important area, where process returns, source reduction, recycling, materials substitution, reuse of materials and waste disposal, as well as refurbishing, repair and remanufacturing and naturally, product recalls through its direct impact on cost of quality (Fassoula 2005, Giuntini and Andel 1995, Stock 1998).

4.2. Reverse Pharmaceuticals

Nowadays, pharmaceutical companies are multi-product, multi-purpose and multi-site facilities operating in different countries and dealing with a global-wide international clientele. Especially in the pharmaceutical industry, it is very often the case that multi-national companies operate in many geographically distributed manufacturing facilities while dealing with an international clientele located in different customer zones. Therefore, the issues related to the trading structure of the company have to be taken into account when deciding on the optimal multi-site investment strategy of the company (Levis and Papageorgiou 2004); therefore, the return of the drug products can be very complex.

Although increasing, the recall or removal from the market of pharmaceutical products is not a regular event. When the product involved is a drug which is being dispensed to hospital patients, a product recall has to be carried out quickly and effectively (Autry 2005, Bowersox and Closs 1996, Ritchie et al. 2000), the replacement with a new one should also be done promptly. Ritchie et al. also state that due to the potential severity of using expired or ineffective drugs, it is critical that pharmaceutical companies get the reverse logistics right from the beginning. Companies must react quickly to problems, as well as clear the supply chain of non-conforming material, so that an appropriate supply chain can be reissued to those waiting for their medications (Kumar et al. 2009), it is possible to reduce the possible transportation costs of returned materials by taking possession when delivering newly manufactured products in the area or to the same client. In this case, it is convenient to design transport to facilitate the delivery of the new products with collection of used materials and products to recover; in this case the coexistence between forward and reverse materials is possible, moreover the incorporation of reverse logistics in the existing supply chain means benefits the manufacturing company, both with regards to quality, by improving customer assistance and product delivers and collection with regard to quantity (de la Fuente et al. 2008).

To sum up, during a drug product recall the company must rely on the distributors or wholesalers distribution information (Kumar et al. 2009), in particular customer service, depot repair, end-of-life manufacturing, IT management, recycling, refurbishing/screening, replacement management, returns authorization, spare parts management, transportation, warehousing and warranty management (Kumar and Putman 2008).

5. DISCUSSION

The impact of returns is ignored, or at minimum, not well-understood in many firms. In others, returns are often considered just a necessary cost-of-doing business (Blackburn et al. 2004). With such perspective, firms focus on cost minimization at an operational level, missing opportunities to recapture value for themselves and their customers, and build customer loyalty (Mollenkopft et al. 2007). Managing costs as well as customer relationships highlights the strategic role that both marketing and operations functions can perform in returns management. Effective returns processing can contribute to customer's perception of value in dealing with a supplier firm. Much of the value created through these activities relates to the physical flow of returned product, and the timeliness and accuracy of the operations group in processing such products. Linked to the operational processing is the ability to the accounting group to reconcile physical flows with financial and information flows in order to issue credit in a timely and accurate manner (Stock and Mulki 2009). On the reverse logistics side, if the company performing the returns function on behalf of the manufacturer has adopted the right systems and technology to perform those tasks, there are a number of efficiencies that can be gained. Moreover, firms that effectively manage the reverse flow of goods benefit through decreased resource investment levels and cost reduction. It has been predicted that firms that choose to formalize their reverse logistics programs may be rewarded in two ways, via improved management of liberally flowing returns and subsequently, increases in overall reverse logistics effectiveness (Autry 2005).

Product quality can affect a customer's sense of value in multiple ways. Ultimately, consumers or end users will evaluate the value they receive from the use of a product, and will evaluate cost/benefits associated with the price paid (Bowman and Ambrosini 2000; Gronroos 2008). Poor quality products will create excessive return situations for retailers, creating operational and profitability concerns for them. Similarly poor packaging quality can induce transit damage or product degradation when in storage or on the retail shelf. Retailers may perceive customer value through supplier efforts to certify product quality and to ensure compliance with industry or regulatory standards (Mollenkopf et al. 2011). Organizations of any size increasingly stress their efforts at cost reduction and continuous improvement of customer satisfaction, which are the main parameters of competiveness. Cost of quality, although it is not established as a component of the final cost and is separately measured in all organizations, is a metric reflecting the overall performance of an organization in relation to both those parameters and it can be used as a progress indicator. Reverse logistics management can provide a continuing and proactive commitment to delivering value for money, by eliminating waste without in any way diminishing the quality level (Ritchie et al. 2000)

To sum up, the strategic importance of effectively managing returns is becoming increasingly evident as firms seek to maximize the value they create for themselves and for customers. When firms view returns as just a cost center or a regulatory compliance issue, they miss potential value that can be created for themselves and their customers. Mollenkopf and Closs (2005) point out this value can only be created by understanding the multi-functional components of marketing, logistics, operations and finance/ accounting functions which actively engage in managing return products (Mollenkopf et al. 2007, Skinner et al. 2008). This is also in line with Souza et al. (2007) regarding the necessity for pharmaceutical companies to identify the product attributes that most affect quality so that operation managers can tap internal sources, including sales, marketing, product development and technical staff. Integration of QA processes is also a critical success factor. Part of this should involve the joint development and maintaining of performance metrics between the service provider and their business partners. Building performance metrics into the service agreement should also be given consideration, with on-going measurement of results taking place on a quarterly or yearly basis (Sartori 2011). No effective medicine is without risk and the benefits of a medicinal product always need to be weighted up against its risks. The challenge to regulators is to find the right balance between timely availability of new medicines and the fact that knowledge on the safety profile is limited at the time of marketing authorization (EMA 2011).

To sum up, reverse logistics is an important component of the supply chain in particular when dealing with product recalls and trade return (Startori 2011).

6. MANAGERIAL IMPLICATIONS

Managers can take away several relevant points from this preliminary research.
First, in the area of product recalls, constructive responses to product defects by recalling defective products could perhaps be seen as positive efforts towards corporate responsibility and accountability; whereby the existence of what could be viewed as socially responsible practices could mitigate the adverse reactions arising from product recalls, and in doing so, protect the long-term interest of the stakeholders of the firms (Yaros and Wood 1979). Additionally, manufacturers choose to engage in reverse logistics and particularly product recovery to reduce production cost, meet customer demand, enhance brand image, and protect after-market. In some cases, manufacturers are forced to set up reverse supply chains because of environmental regulations or to meet customer requests or both (Ordoobadi, 2009).
Second, monitoring and responding to the external factors which influence returns. As customer, competitiveness and regulatory environments continue to change, returns are an increasingly important component in managing 'green', consumer protection and legislative issues. Also, these external factors may impact physical, information and financial flows in the supply chain.

Third, effectiveness of returns management seems to be enhanced when functional areas within the firm coordinate their strategic and operational activities. Managers, who do so, realize that effective handling of reverse logistics transactions can result in economic and strategic benefits. As reverse logistic programs become more formalized, returns handling capabilities are more likely to yield performance gains such as increased profitability or reduced inventory investment (Autry 2005).

Fourth, integrating reverse supply chain with activities and processes in the forward supply chains can reduce transportation costs through convenient transport design which will facilitate the delivery of the new products with collection of used materials and products to recover (de la Fuente et al. 2008, Mollenkopf et al. 2007).

Lastly, focusing resources on the product and process attributes is truly critical for delivering quality products. Adding quality measures to manufacturing process midstream may simplify quality and compliance-management systems. Working to monitor and measure quality performance effectively will lead quality improvement and lower the risk of compliance issues. Companies that succeed in implementing these changes can create a competitive advantage through superior performance on cost and quality: dramatically reducing variability, the risk on noncompliance, and time to market, while freeing up funds for investment (Souza et al. 2007).

To sum up, due to the challenging regulatory environment as Souza et al. (2007) refer, pharmaceutical companies should find ways to improve quality and costs considerably. Creating a culture where quality objectives are transparent, well understood, and undoubtedly important may drive companies to beneficial changes where quality objectives are clear leading to the progressive alignment of several areas of operations including sales, marketing, product-development, and technical staff.

7. CONCLUSION

Our purpose in this research was to develop an understanding of the linkage between reverse logistics and the pharmaceutical industry quality issues. A systemic review of the literature was conducted in an aggregated view, despite the scarceness of the literature in the reverse pharmaceutical field. While we focused our attention on the benefits of reverse logistics as a strategic tool towards pharmaceutical returns, we discovered that other factors should be incorporated into such research. Additionally, we identified several other features that may influence the process; nevertheless there are other aspects we have not yet exposed like, evaluate whether drug product recalls are happening more in the originator or generics as well as domestic or foreign manufacturers. Based on this work, we completed the next step in the preliminary research agenda to follow the phenomenon in the pharmaceutical industry.

REFERENCES

Abboud L and Henslye S (2003) "New prescription for drug makers: Update the plant", *The Wall Street Journal,* September 3.
Almor T, Tarba S and Benjamin H (2009) "Unmasking integration challenges: The case of Biogal's acquisition by Teva Pharmaceutical Industries", *International Studies of Management and Challenges*, Vol. 39, No. 3, Fall 2009, pp. 32-52
Autry C (2005) "Formalization of reverse logistics programs: A strategy for managing liberalized returns", *International Marketing Management*, vol. 34, pp. 749-757
Avellanet J (2010) 'John Avellanet on holistic pharma compliance and quality', June 2010, Available at: http://www.pharmaqbd.com [Accessed 3 June 2010].
Blackburn J, Guide J, Douza G and van Wassenhone L (2004) "Reverse supply chains for commercial returns", *California Management Review*, vol. 46, no.2, pp. 6-22
Bowersox D and Closs D (1996) *Logistical management: The integrated supply chain process*, McGrow-Hill International Editions, London
Bowman C and Ambrosini V (2000) "Value creation versus value capture: towards a coherent definition of value integrity", *British Journal of Management*, vol. 11, pp.1-15
Cristopher M (1998) *Logistics and Supply Chain Management*, 2nd ed. Pitman, London
Cheah E, Chan W and Chieng C (2007) "The corporate social responsibility of pharmaceutical product recalls: An empirical examination of US and UK markets", *Journal of Business Ethics*, vol. 76 pp. 427-449
CNNMoney.com (2010), "Drug Recalls Surge", Available at: www.cnn.com/2010/08/16/news/companies/drug_recall_surge/index.htm, [Assessed April 17, 2011]
Dale B (2003) *Managing Quality*, 4th ed. Blackwell Publishing, Oxford
de la Fuente M, Ros L and Cardós M (2008) "Integrating forward and reverse supply chains: application to a metal-mechanic company", *Int. Journal of Production Economics*, vol. 111, pp. 782-792
Doherty K (1996) "What goes around comes back", *US Distribution Journal,* vol. 223, no. 10, pp. 40-44
Eduards A (2010) "Manufacturing the future, Integrated collaboration between CMOs and

Sponsors", Available at: www.contractpharma.com/articles/2010/05/manufacturing-the-future [Assessed 15 May 2010]
EMA (2007) "An Analysis of Quality Product Defects in Centralized Procedure", Available at: http://www.ema.europa.eu [Assessed January 7, 2011]
Fassoula E (2005) "Reverse logistics as a means of reducing the cost of quality", *Total Quality Management & Business Excellence*, vol. 16, no. 5, pp. 631-643
Food and Drug Administration (2007) "CDER Facts and Figures", Available at: http://www.fda.gov/Drugs/DrugSafety/default.htm [Assessed 7 January 2011]
Feigenbaum A and Feigenbaum D (1999) "New quality for the twenty-first century: developments are the fundamental drivers of business", *Quality Progress*, December, pp. 27-31
Giutini R and Andel T (1995) "Master the six Rs of reverse logistics", *Transportation & Distribution*, vol. 36, no. 3, pp. 93-97
Granauer T, Scherrer-Rathje M and Friedli T (2009) "A reference framework to sustainably implement operational excellence in the pharmaceutical industry", EurOMA 2009 Proceedings. Available at: www.euroma2009.org/Proceedings [Assessed 15 May 2010]
Gronroos C (2008) "Service logistics revisited: who creates value and who co-creates", *European Business Review*, vol. 20, no. 4, pp. 298-314
Handerson J, MacGoldrick E and McAdam R (2003) "A critical review of e-service in Northern Ireland Electricity", *Managing Service Quality*, vol. 13, no. 6, pp. 436-70
International Conference on Harmonization: Available at: http://www.ich.org/products/guidelines/quality/article/quality-guidelines.html [Assessed 7 January 2011]
IMS Health (2010), Available at: http://www.imshealth.com/portal/site/imshealth [Assessed April 17, 2011]
Kolbe R, Brunette M (1991) "Content analysis research: an examination of applications with directives for improving research, reliability and objectivity", *Journal of Consumer Research*, vol. 18, no. 2, pp. 243–50
Kumar S, Dieveney E and Dieveney A (2009) "Reverse logistic process control measures for the pharmaceutical supply chain", *International Journal of Productivity and Performance Management*, vol. 58, no. 2, pp. 188-204
Kumar S and Putman V (2008) "Cradle to cradle: reverse logistics and opportunities across three industry sectors", *Int. Journal of Production Economics*, vol. 115, pp. 305-315
Kumar S, Dieveney E and Dieveney A (2009) "Reverse logistics process control measures for the pharmaceutical industry supply chain", *International Journal of Productivity and Performance*, Vol. 58, No. 2, p.188-204
Krumwiede D and Sheu C (2002) "A model for reverse logistics entry by third-party providers", *Omega*, Vol. 30, pp. 325-333
Levis A and Papageorgiou L (2004) "A hierarchical solution approach for multi-site capacity planning under uncertainty in the pharmaceutical industry", *Computers and Chemical Engineering*, vol. 28, pp. 707-725
Li L and Collier D (2000) "The role of technology and quality on hospital financial performance", *International Journal of Service Industry Management*, vol. 11, no. 3, pp. 202-24
Li G, Ooi B, Feng J, Wang J and Zhou L (2008) "EASE: An Effective 3-in-1 Keyword Search Method for Unstructured, Semi-structured and Structured Data", Proceedings of the ACM SIGMOD International Conference on Management Data. Available at: http://dbgroup.cs.tsinghua.edu.cn/ligl/papers/SIGMOD2008-EASE.pdf [Assessed 30 August 2010]
Mahboubian-Jones G (2009) 'Toyota and lesson for pharma top managers', Available at: http://www.pharmaqbd.com [Accessed 3 June 2010]
McConnell J, Nunnally B and McGarvey B (2009) "Variation – Past, present, and future", *Journal of Validation Technology*, Spring 2009, pp. 37-42
Melbin J (1995) "The never ending cycle", *Distribution*, vol. 94, no. 11, pp. 36-39
Mollenkopf D, Frankel R and Russo I (2011) "Creating value through returns management: Exploring the marketing-operations interface", *Journal of Operations Management*, *Article in Press*.

Mollenkopf D, Russo I, and Frankel R (2007) "The returns management process in supply chain strategy", *International Journal of Physical Distribution and Logistics Management*, vol. 37, no. 7, pp. 568-592
Mollenkopf D and Closs D (2005) "The hidden value in reverse logistics", *Supply chain management review*, July/August, pp. 34-43
Ordoobadi S (2009) "Outsourcing reverse logistics and remanufacturing functions: a conceptual strategic model", *Management Research News*, vol. 32, no. 9, pp. 831-845
Papageorgiou L, Rotstein G and Shah N (2001) "Strategic supply chain optimization of the pharmaceutical industries", *Ind. Eng. Chem. Resources*, vol. 40, pp. 275-286
Pharmaceutical Market Trends, 2010-2014 (2010) http://www.pharmaceutical-marketresearch.com/publications/general_industry/pharmaceutical_market_trends_2008_2012.html [Assessed April 17, 2011]
Pluta P and Poska R (2010) "Compliance by Design (CbD) and Compliance Master Plan (CMP) – An Organized Approach to Compliance", *Journal of GXP Compliance*, vol. 14, no. 2, pp. 73-82
Ritchie L, Burnes B, Whittle P and Hey R (2000) "The benefits of reverse logistics: the case of the Manchester royal infirmary pharmacy", *Supply Chain Management*, vol. 5, no. 5, pp. 226
Sartori G (2011) "Reverse logistics role in securing pharmaceutical supply chain", *Reverse Logistics Magazine*, Edition 16
Skinner L, Bryant P and Richey R (2008) "Examining the impact of reverse logistics disposition strategies", *International Journal of Physical Distribution & Logistics Management*, vol. 38, no. 7, p. 518-539
Souza A, Keeling D and Phillips R (2007) "Improving quality in pharma manufacturing", *The McKinsey Quarterly*
Stegemann S (2010) "Better by design" Available at: http://www.worldpharmaceuticals.net/editorials/017-march10/WPF017_better-by-design.pdf [Assessed April 17, 2011]
Stock J and Mulki J (2009) "Product returns processing: an examination of practices of manufacturers, wholesalers/distributors, and retailers", *Journal of Business Logistics,* vol. 30, no.1, pp. 33-62
Stock J (1998) "Development and Implementation of Reverse Logistics Programs", *Council of Logistics Management, Annual Conference Proceeding*
Reuters online (2009), 'CBR Pharma Insights: The New Pharmaceutical Sales Force - Key Trends Shaping Future Sales Strategies', Available at: http://www.reuters.com/article/pressRelease/idUS116884+06-Apr-2009+BW20090406 [Accessed July 2009]
Yaros S and Wood F (1979) "Recalling products in the drug cosmetic industry", *Journal of Business Logistics*, vol. 1, no. 2, pp. 48-59

SUSTAINABLE PHARMACEUTICAL SUPPLY CHAINS: A STATE OF THE ART REVIEW

Ana Margarida Santos Bravo[1], José Crespo de Carvalho[2]
[1]Researcher in Pharmaceutical Supply Chains - ISCTE –IUL – Lisbon University Institute, Lisbon, Portugal, margarida.bravo@gmail.com
[2] Full Professor, ISCTE – IUL – Lisbon University Institute, Lisbon, Portugal
crespo.carvalho@gmail.com

ABSTRACT

1. INTRODUCTION

Pharmaceutical companies are undergoing major change to cope with the new challenges of the global economy. Intensive globalization processes, increased competitiveness, fast changing structure of competitors, complex strategic positioning, shrinking pipelines, expiring patents, counterfeit drugs, increased regulatory scrutiny on profits and a fight for global market share, are some of the factors giving pharmaceutical companies new challenges (Papageorgiou et al. 2001, Reuters 2009, Almor 2009, Edwards 2010).

Moreover, pharmaceutical companies underlie strong regulations dictated by the FDA (Food and Drugs Administration) and EMA (European Medicines Agency), for example; Complex requirements are forcing pharmaceutical manufacturers to adopt more formal business processes and stricter reporting methods (Souza et al. 2005).

Organizations that cannot show a clear ethical conscience in supply risk significant tend to see their customers change their preferences to rival companies over time (Harwood and Humby 2008). These drivers show how organizations are facing increasing pressures from a wider range of stakeholders to engage with social and environmental corporate responsibility activities.

Consequently, the purpose of this paper is to review the state of the art on sustainable supply chains and merge it with the pharmaceutical industry. This poster is structured as follows; first a review of the literature was conducted, the merge between the outcomes of the review in terms of sustainability and the pharmaceutical industry is next. Finally, managerial implications, discussion, future work and conclusions.

1. LITERATURE REVIEW

A systemic review was conducted with the purpose of gather information from both scientific and grey literature that could show a full picture of the advantages and initiatives as well as the limitation found in pharmaceutical industry towards sustainability. We first adopted a keyword search in electronic databases such as ProQuest, Elsevier, Emerald, Springer, Science Direct, Interscience and Google scholar, in order to find articles only related to pharmaceutical supply chain sustainability, followed by content analysis. Cited references were examined as second sources.

According to Fink (1998), a literature review is a systemic, explicit, and reproducible design for identifying, evaluating and interpreting the existing body of recorded documents. Summarizing existing research by identifying patters, themes and issues; as well as helping to identify conceptual content of the field which can also contribute to theory development, are some of the main objectives of literature review. Methodologically, literature reviews can be understood as a content analysis, where quantitative and qualitative features are combined to evaluate structural, descriptive and content criteria (Seuring and Muller 2008).
Taking the stated delimitations into account, a total of 60 papers were identified. The basic body of literature identified comprises 35 papers. The portion of the researched publications was established in the research period between 1979-2011.

2. SUSTAINABILITY

First, we shall present a couple of definitions for the purpose of this research. Sustainable development and Sustainable supply chains. Using resources to meet the need of the present without compromising the ability of future generations, Pursuing the balance between the three main dimensions economic, environmental and social performance (3BL); in addition to going beyond legal compliance, achieving human development in an inclusive, connected, equitable, prudent and secure manner (Veleva et al. 2003, Kleindorfer et al. 2005, Székely and Knirsch 2005, Jorgensen 2008, Foerstl et al. 2010, Hart and Milstein 2003, Norman and Macdonals 2004) is the most consensus definition firstly disclosed from the World Commission for Economic Development (WCED).

Complementarily, sustainable development comes from focusing in the supply chain, where the product, management of material, information and capital flows as well as the cooperation among companies along the supply chain is considered from its initial raw a material processing until it is delivered to the end customer (Linton et al. 2007, Seuring and Muller 2008, Hart and Milstein, 2003, Sarkis 2001) and back with improvement of the social and environmental impacts explicitly considered (Jorgensen and Knudsen, 2006).

In sustainable supply chains, environmental and social criteria should be fulfilled by all members of the supply chain; however, it is expected that competitiveness would be maintained through meeting customer needs and related economic criteria, which are derived from customer and stakeholder requirements, nevertheless, the main aim is to satisfy customers and gain competitive advantage in the market (Seuring and Muller 2008). Moreover, according to Jorgensen (2008), for a company to move towards a sustainable management system, it is necessary to focus on integration of the different management standards, in particular, environmental management system ISO 14001, social accountability 8000 (SA 8000) or codes of conduct. According to Boyed et al*.* (2007) integrating supply chains improve a firm's competitive capabilities by lowering production transaction costs, accelerating the development of new products, and providing the firm access to needed resources and knowledge. In addition, the cooperation with suppliers increases in importance, in particular the integration of the complete supply chain from raw materials to final customers (Linton et al*.* 2007, Seuring and Muller 2008). On the other hand, sustainable supplier management should go beyond supplier self-declaration of compliance to standards and encompass effective systems (Green et al. 1996). Especially increasing reliance on global supply base increases the need for supply risk management (Wagner and Bode 2006) in particular, for active management of supplier sustainability risks (Baden el al. in press, Linton et al. 2007, Forerstl et al. 2010). Globally, manufacturers have developed and implemented broad programs to control and improve their environmental practices across the entire supply chain (Rao 2002). These involve environment-related interactions with upstream suppliers and with downstream customers.

3. PHARMACEUTICAL SUSTAINABILITY

Companies could significantly be influenced by regional and cultural characteristics (Sarkis et al. 2010). As the industry experiences an increasing pressure from regulation markets in the demand for more sustainable products, the need to become more sustainable increases, and the responsibility of its activities should be expanded from the production site to the whole product chain (Jorgensen 2008, Linton et al. 2007). The pharmaceutical industry is exactly such example. Increased global development and competition have pushed many industries to operate on a much more global level. Together with increased outsourcing, the number of companies involved in a typical supply chain has greatly increased. Due to this, several companies have introduced supplier evaluation schemes which integrate environmental and social criteria. Related measures include supplier self-evaluation where suppliers have to declare how they deal with environmental and social standards which set minimum requirements.

A corporation may be held socially and ethically accountable by an expansive array of stakeholders such as employees, consumers, governments, communities, NGO's, investors, supply chain members, unions, regulators, the media and even the broader society including future generations (Maloni and Brown 2006). Moreover, for a supply chain perspective, Carter and Jennings (2002) shown that, CSR is not only synonymous with business ethics, but also covers other dimensions such as philanthropy, community, workplace, diversity, safety, human rights, cause-related marketing, minority support, socially responsible employment and manufacturing processes (Maloni and Brown 2006). Carter (2000) refers to CSR as a positive link between environmental purchasing and financial performance.

Pharmaceutical companies are using the Global Reporting Initiative (GRI) as a way to implement and measure their level of sustainability. The GRI was established in 1997 by the coalition for Environmental responsible Economies (CERES). It is a voluntary initiative intended to be a valuable tool for all levels of decision-makers in a company, from senior management to operational level and for internal and external stakeholders. The goal is to have a globally applicable framework for company-level sustainability reporting that links all three aspects of sustainability: environmental, economic and social. The GRI guidelines have been developed and revised through a process involving various stakeholders (GRI 2011). As part of the standard sustainability report, the GRI guidelines suggest the use of indicators to measure an organizations performance in environmental, social and economic areas. They list over 100 possible indicators for companies to use, both generally applicable and organization-specific. For environment indicators i.e., total energy use, total water use, greenhouse gas emissions in tons of CO_2 equivalent, total waste, and supplier performance. Regarding organizations-specific indicators include the use of recycle material, use of packaging materials, and water sources significantly affected by organizations use of water. The GRI guidelines act as an educational vehicle and promote corporate social responsibility reporting for integrating environmental, social and economic aspects, and promote transparency and improved dialogue between business and stakeholders (Veleva and Ellenbecker 2001). In addition, due to the fact that financial and social criteria are crucial parts, these truly differentiate 'sustainability' reporting from straight environmental reporting (Morhardt and Freedman 2002).

The sustainability Report from 2009 for the pharmaceutical industry revealed the PSI scores (Pacific Sustainability Index (PSI) which uses two systemic questionnaires: one base questionnaire for reports across sectors and a sector specific questionnaire for companies within the same sector) for 26 largest pharmaceutical companied in the world. The findings of the reports include: 1) companies in the pharmaceuticals sector place varying importance on sustainability reporting transparency; 2) As in many sectors, environmental performance was the most underreported section. Fewer than half of the sector's companies reported using environmental accounting, green purchasing and chemistry, or concern for biodiversity, and fewer than 60% of the companies mentioned climate change; 3) Across the sector, social reporting scores were generally better than scores for environmental reporting; 4) the pharmaceutical sector certainly should continue to address social issues on which it has a direct effect, such as health disparities, as well as the important environmental challenges all corporations face; 5) Many pharmaceutical companies have room for extensive improvements in their sustainability reporting, although there are some leaders in the sector setting a 'stellar' example. Ten of the 26 companies in the sample were GRI reporters, all of which finished in the top half of the reports 'Overall Grade' list (Sustainability Report 2009).

4. MANAGERIAL IMPLICATIONS

The adoption of sustainable practices helps business to distinguish them from competition through the reduction of unnecessary risks, generation of waste, increasing efficiency of materials and energy, innovating by new and environmental friendly products and services as well as gaining operating licenses from local communities (Székely and Knirsch 2005), and as soon as any harm is discovered and brought to the stakeholders attention, its root causes are identified and properly rectified (Campbell 2007). This type of approach leads to the increase business performance and profitability, sustaining their activities longer (Linton et al*.* 2007).

No questions asked, sustainability is of relevant interest, research in this subject has been dedicated on financial impacts of environmental behaviors (Markey and Davis, 2007). Markey and Davis (2007) also refer that little work has been made addressing the impact that a sustainable supply chain, has on the protection of global, green and social capital, can have in a firms overall economic security; as well as the potential development of a competitive advantage using a sustainable supply chain as a base and securing stakeholder approval (Hart 1997). Moreover, Hart (2000) states that it is of increase importance for firms to evaluate the impact that a sustainable supply chain strategy has on the triple bottom line (3BL), due to the challenging global economy, in particular companies should begin to evaluate not only their supply chains impact on their traditional financial bottom line, but also on their social/ethical and environmental performance. Companies have been developing and using environmental sustainability indicators (Veleva and Ellenbecker 2000), as a manner to improve a company's public image gaining competitive advantage through product/service differentiation (Porter 1998, Mahler 2007). In addition, direct interaction with supply chain partners can enable a company to reduce total inquiry levels, decrease product obsolescence, lower transaction costs, react more quickly to changes in the market, and respond more promptly to customer requests. Managers can improve their materials management performance by fist understanding how their decisions affect the purchasing, storage, handling, and asset recovery activities throughout their organization (Markey and Davis 2007).

5. CONCLUSION

Our purpose in this research was to develop an understanding of the linkage between pharmaceutical industry sustainability. A systemic review of the literature was conducted in an aggregated view, despite the scarceness of the literature in the pharmaceutical field. While we focused our attention on the benefits of sustainable supply chains we have identified other factors that should be incorporated into such research. Based on this work, we posit a preliminary research agenda to follow the phenomenon in the pharmaceutical industry.

REFERENCES

Almor T, Tarba S and Benjamin H (2009) "Unmasking Integration Challenges: The Case of Biogal's Acquisition by Teva Pharmaceutical Industries", *International Studies of Management and Challenges*, Vol. 39, No. 3, Fall 2009, pp. 32-52

Boyd D, Spekman R, Kamuff J and Werhane P (2007) "Corporate Social Responsibility in Global Supply chains: A Procedural Justice Perspective", *Long Range Planning*, Vol. 40, pp. 341-356

Campbell J (2007) "Why Would Corporations Behave in Socially Responsible Ways? An Institutional Theory of Corporate Social Responsibility", Academy f Management Review, Vol. 32, No. 3, pp. 946-967

Carter C, Kale R and Grimm C (2000) "Environmental Purchasing and Firm Performance: An Empirical Investigation", *Logistics and Transportation Review*, Vol. 36, No. 3, pp. 219-228

Carter C and Jennings M (2002) "Social Responsibility and Supply Chain Relationships", *Transportation Research,* Part E, no. 38, pp. 37-52

Eduards, A. (2010), "Manufacturing the Future, Integrated collaboration between CMOs and Sponsors". Available at:www.contractpharma.com/articles/2010/05/manufacturing-the-future [Assessed 15 May 2010]

Fink A (1998) "Conducting Research Literature Reviews: from Paper to the Internet", *Thousand Oaks*, Sage

Foerstl K, Reuter C, Hartmann E and Blome C (2010) "Managing supplier sustainability risks in a dynamically changing environment – Sustainable supplier management in the chemical industry", *Journal of Purchasing & Supply Management*, Vol. 16, pp. 118-130.

GRI (2011), Available at www.globalreporing.org [Assessed March 2011]

Green K, Morten B and New S (1996) "Purchasing and Environmental Management: Interactions, Policies and Opportunities", *Business Strategy and the Environment*, Vol. 5, No. 3, pp. 188-97

Hart S and Milstein M (2003) "Creating Sustainable Value", Academy of Management Executive, Vol. 17, -no. 2, pp. 55-69

Hart S (1997) "Beyond greening", *Harvard Business Review* no. 1, pp. 66-76

Howard I and Humby S (2008) "Embedding Corporate Responsibility into Supply: A Snapshot of Progress", *European Management Journal*, Vol. 26, pp. 166-174

Jorgensen T (2008) "Towards more Sustainable Management Systems: through Life Cycle Management and Integration", *Journal of Cleaner Production*, Vol. 16, pp. 1071-1080

Jorgensen A and Knudsen J (2006), "Sustainable Competitiveness in Global Value Chains: How do Small Danish Firms Behave?", *Corporate Governance*, Vol. 6, Iss. 4, pp. 449-462

Kleindorfer P, Singhal K and van Wassenhove L (2005) "Sustainable Operations and Production Management", *Production and Operations Management*, Vol. 20, No. 2, pp. 225-248

Linton J, Klassen R and Jayaram V (2007) "Sustainable Supply Chains: An Introduction",

Journal of Operations Management, Vol. 25, pp. 1075-1082
Mahler D (2007) "The Sustainable Supply Chain", *Supply Chain Management Review*, Vol. 11, No. 8, pp. 59
Maloni M and Brown M (2006) "Corporate Social Responsibility in the Supply Chain: An Application in the Food Industry", *Journal of Business Ethics*, Vol. 68, No. 1, pp. 35-52.
Markley M and Davis L (2007) "Exploring future competitive advantage through sustainable supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 37, no. 9, pp. 763-774
Morhardt J, Baird S and Freeman K (2002) "Scoring Corporate Environmental and Sustainability using GRI 2000, ISO 14031 and Other Criteria", *Corporate Social Responsibility and Environmental Management*, Vol.9, pp. 215-333
Norman W and MacDonal C (2004) "Getting to the bottom of 'triple-bottom-line'", *Business Ethics Quarterly*, Vol. 14, No. 2, pp. 243-62
Papageorgiou L, Rotstein G and Shah N (2001) "Strategic Supply Chain Optimization for the Pharmaceutical Industries", *Ind. Eng. Chemical Resources*, Vol. 40, pp. 275-286
Porter M (1998) "Competitive Advantage: Creating and Sustaining Superior Performance", *The Free Press*, New York
Rao P (2002) "Greening Supply Chain: A New Initiative in South East Asia", *International Journal of Operations & Production Management*, Vol. 22, no. 6 pp. 632-655.
Reuters online (2009), 'CBR Pharma Insights: The New Pharmaceutical Sales Force - Key Trends Shaping Future Sales Strategies', Published: April 6, 2009, Last updated April 6, 2009.08:00, Available at:
http://www.reuters.com/article/pressRelease/idUS116884+06-Apr-2009+BW20090406
[Accessed July 2009]
Souza D, Danase J and Constatinou D (2005), Business Efficiency and Regulatory.
Sarkis J, Helms M and Hervani A (2010) "Reverse Logistics and Social Sustainability", *Corporate Social Responsibility and Environmental Management*
Sarkis J, Gonzalez-Torre P and Adenso-Diaz B (2010) "Stakeholder Pressure and the Adoption of Environmental Practices: The mediating Effect of Training", *Journal of Operations Management,* Vol. 28, pp. 163-176
Seurig S and Muller M (2008) "From a literature Review to a Conceptual Framework for Sustainable Supply Chain Management", *Journal of Cleaner Production*, Vol. 16, pp. 1699-1710
Székely F and Knirsch M (2005) "Responsible Leadership and Corporate Social Responsibility: Metrics for Sustainable Performance", *European Management Journal*, Vol. 23, No. 6, pp. 628-647
Veleva V, Hart M, Greiner T, Crumbley C (2003), "Indicators for Measuring Environmental Sustainability: A Case Study of the Pharmaceutical Industry", *Benchmarking: An International Journal*, Vol. 10, No. 2, pp. 107-119
Veleva V and Ellenbecker M (2001) "Indicators of Sustainable Production: Framework and Methodology", *Journal of Cleaner Production*, Vol. 9, No. 6, pp. 519-49
Veleva V and Ellenbecker M (2000) "A Proposal for Measuring Business Sustainability: Addressing Shortcomings in Existing Frameworks", *Greener Management International,* Autumn, No. 31, pp. 101-20.
Wagner S and Bode C (2006) "An Empirical Investigation into Supply Chain Vulnerability", *Journal of Purchasing and Supply Management*, Vol. 12, Iss. 6, pp. 301-331

SUSTAINABLE SUPPLY CHAINS IN A GLOBALISED WORLD

Matthias Klumpp, Wolfgang Kersten**, Sebastian Brockhaus***

* Institute for Logistics & Service Management (ild),
FOM University of Applied Sciences Essen, Germany
Phone: +49 (0) 201 81004-554, E-Mail: matthias.klumpp@fom-ild.de
** Hamburg University of Technology (TUHH), Germany
Phone: +49 (0) 40 42878-3525, E-Mail: logu@tuhh.de

ABSTRACT
A sustainability approach for global supply and transport chains is an important topic in the field of logistics, especially on a global scale. This research contribution outlines an overarching concept as Total Sustainability Management Concept in order to integrate today's segregated streams of research discussions regarding green logistics. This concept is also described in certain details in order to bear fruits in practical business contexts as well as in further research endeavours.

Keywords: Green Logistics, Sustainability, Total Sustainability Management Concept

1. INTRODUCTION

A sustainability approach for global supply and transport chains is a prominently discussed topic in the field of business administration and logistics. In this area the emergence of several new topics besides the traditional objectives of logistics management concepts can be observed. Some examples are provided by the following questions:

- What is a sustainable supply chain (greener versus green logistics)?
- How can an overall sustainability measurement be developed and standardized?
- How can CO2 measurements be standardized globally?
- Which action fields can be identified and are important for future sustainable supply chains?
- How can standardized and effective management methods be applied globally to tackle the problems of greener logistics?

The research findings address the described areas of an integrated sustainability concept regarding the following hypotheses:

(1) The basis for sustainable concepts is provided by definitions and measurement standards e.g. regarding global CO_2 measurement.
(2) Green logistics management concepts have to include reduction instruments regarding energy consumption and emissions for example by avoiding transport or using new motor and energy concepts (hybrid drives, sky sails etc.).
(3) Future sustainable concepts have to include compensation concepts regarding e.g. carbon offsetting and even possible damage control funds in order to support areas and countries which undergo severe problems due to climate change.
(4) Finally, all the concepts and measures mentioned have to be implemented on a global scale in order to be suitable for global supply chains. This may require new global standards or even institutions.

This concept is also supplemented by a first modelling approach to provide for a simulation and decision support option. The special value of this paper is to start the international research discourse about an integrated sustainability management model in logistics so that guidance and standards for research as well as business practice are provided in order to support future green logistics developments. Especially gaps for specific research and management topics are identified by this integrated approach.

2. SUSTAINABLE LOGISTICS CONCEPT AND RESEARCH METHODOLOGY

These research questions above point to the fact that an overall holistic approach is needed to integrate all areas and concepts of green logistics in order to provide for a global basis and understanding of necessary logistics management instruments. This is addressed by this research paper by integrating existing research into a "Total Sustainability Management" (TSM) concept for logistics. The following figure 1 is illustrating this idea in a first draft to be outlined further in this paper.

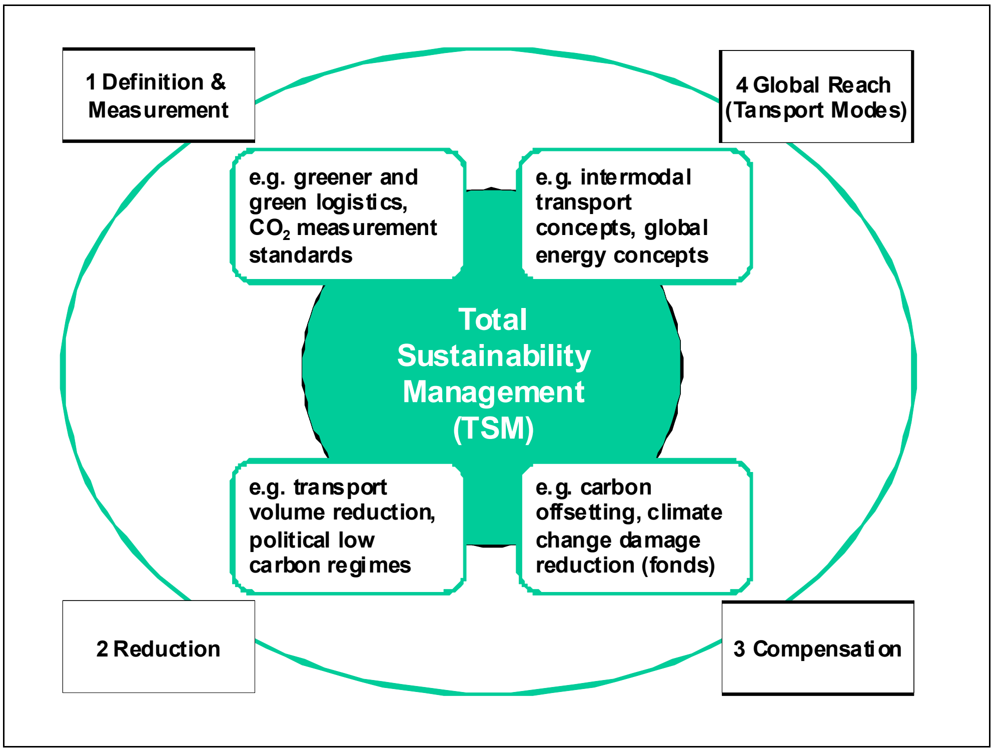


Figure 1: Total Sustainability Management Concept Draft.

This described sustainability concept on a *strategic* or supply chain level has to be translated into *operative* measures influencing daily logistics processes in a greener logistics perspective. Therefore the following chapter will outline the possible activities and decision areas that enable actual daily improvement impacts in terms of systemic sustainability by logistics. The *methodology* used in this research is a combination of literature review ('bottom up approach') and conceptual work ('top down approach') in order to piece together an integrated concept for sustainable logistics.

3. SUSTAINABLE LOGISTICS DETAILS

3.1. Definition & Measurement

Sustainability as defined by the concept of the triple bottom line (TBL), seeks a long-lasting balance between economic, social and environmental aspects of business (Elkington 1998). In a logistics context, the TBL touches on every dimension of the logistics service such as transportation, storage, handling, etc. Although criticism of the TBL concept and its applicability has been voiced repeatedly (e.g. Norman & MacDonald 2004), the approach provides a comprehensive starting point for the integration of environmental and social issues in business. However, we agree with the critics that TBL and the definition of sustainability put forward in the Brundtland Report: "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p.8) as the main origin of the term sustainability in its present meaning, lack a direct applicability to business and logistics. Especially the question whether sustainability should be treated as a relative concept (something can be more/less sustainable than something else) or an absolute concept (something is either sustainable or it is not) proves to be highly relevant but lacks a conclusive answer yet.

Alternative understandings of sustainability, for example the book by John Ehrenfeld (2008), have shed further light on the problems of finding a suitable definition (in particular on the relative-vs.-absolute-view debate) but have done little in the way of facilitating easier implementation of the concept as they have proven to be even more abstract. Although in the past century, various attempts have been made to develop the issue towards a more direct practicality in the business context (e.g. Epstein & Roy 2003; Bekefi & Epstein 2008; Stavins et al. 2003) literature still finds companies struggling to get on top of the development (Baumgartner & Ebner 2010; Lubin & Esty 2010). We hypothesize that part of the reason for this is the aforementioned overwhelming scope of sustainability and the confusion created by the lack of one single comprehensive definition of the term. However, previous work (Kersten et al. 2010) has led us to believe that yet another attempt to define sustainability differently will not prove to be the panacea but will simply add further complexity and uncertainty.

Therefore, in order to provide the necessary "theoretical lens" (Amundson 1998, p.345) the TSM concept of this manuscript will attempt to combine a piecemeal approach (we dissect the sustainability challenge by severely limiting the scope and focus of the research) with an integrated concept to tie all the loose ends together with the goal of "capturing the sustainability city, house by house". This paper will therefore limit its view to two dimensions of the TBL: environmental and economic and their interplay. In other words, this manuscript will look at the "green" aspects of sustainability and their use and implementation in the logistics world. The emissions of greenhouses gases (GHG) relative to unit of output will be employed as the major indicator for the environmental performance of logistics services. We will direct our focus at logistics specifically because research has shown logistics can be a major field to improve the environmental impact of companies through a reduction of their GHG emissions (Capoor & Ambrosi 2008). While green approaches should never be limited to GHG only as they merely represent one part of the environmental considerations of logistics – a good overview of the diverse environmental impact of logistics can be found in Wu & Dunn (1995) – the GHG emissions provide a good proxy for the environmental sustainability of logistics (Abukhader & Jönson 2004; de Burgos Jiménez & Lorente 2001; Veleva et al. 2001) and are often used as such for research purposes (e.g. McKinnon 2007; Wolf & Seuring 2010). Concerning the measurement of GHG emissions, the GHG-Protocol by the World Resources Institute (2004, 2009) provides guidance for practical implementation. While these guidelines allow companies to assess their GHG emissions with fair accuracy, an exact measurement of the environmental impact is in need of further refinement (Westlund 2001).

Companies assessing their GHG-emissions and other environmental impact have the opportunity to aim for certification of their sustainability efforts, for example through ISO 14001. The ISO norm requires companies to implement an environmental management system (EMS) to monitor and improve their impact. Successful implementation of an EMS is a good indicator for sound sustainability management practice (Delmas 2001; Bansal & Hunter 2003). It should be taken into account that the implementation of an EMS alone does not guarantee superior sustainability performance (Rondinelli & Vastag 2000) but it certainly makes for a good foundation of the effort and can be used for signalling the environmental commitment of the company.

As mentioned, a major pitfall for the current sustainability understanding is the question of the absolute vs. the relative view. A feasible concept of an absolute understanding would imply a clearly defined system with known limits for the emissions allowed and the total amount of resources available. As the current knowledge of the worlds' ecosystem and its interrelations with the economy is hardly sufficient to accurately derive these figures, an absolute approach to sustainability is currently not practically implementable. We therefore retreat to employing a relative approach to sustainability, allowing for products, services and even whole economies to be more/less sustainable compared to others. Furthermore, their sustainability can change over time and they can become "more sustainable" as their environmental and social impact are enhanced (Faber et al. 2005). As we limit our scope to the environmental or green aspects of sustainability, for the remainder of this manuscript the term "greener" will be employed. Our focus will thus be "greener logistics" – defined as all logistics concepts that allow the reduction of environmental impact per unit of output. Since our approach aims at simultaneously reducing environmental impact and enhancing financial profit (thus satisfying the ecological and economical dimension of the TBL) the logical conclusion also suggested by literature is to improve the efficiency of logistics by reducing the amount of natural resources (i.e. energy) and financial resources (i.e. money) per unit of output. The following section 3.2. provides insights on how this reduction can be achieved while section 3.3. points out ways to improve the environmental performance through ways of compensation if the efficiency cannot be further enhanced.

3.2. Reduction

The natural way of enhancing efficiency in any kind of process is to reduce waste. The term waste in this paper is used to describe all kinds of resource consumption not efficiently directed at producing the product the consumer desires (Becker 2008). This understanding of waste was first introduced by Taiichi Ohno as "muda" (1988, p.19 f.) as a part of the Toyota Production System and will be further employed in the context of greener logistics here. As indicated in the previous paragraph, it has been established by research that efficient logistics processes with minimal waste (i.e. lean logistics) are the key to greener logistics (e.g. Mollenkopf et al. 2010; Kersten et al. 2010). Pollution indicates inefficiencies and thus a waste of resources and profit at the same time (Porter & Van der Linde 1995a, Porter & Van der Linde 1995b; Burson 2008). Therefore, efficient systems are required to reduce undesired by-products or turn them into sellable products. In particular closed-looped systems can eliminate waste almost completely (e.g. Flapper et al. 2005; Ferguson & Souza 2010; Fleischmann et al. 2003; Huang et al. 2009; Drake & Ferguson 2008; Atasu et al. 2008). Implementation of closed-looped systems in practice has proven challenging but rewarding (Morana & Seuring 2007).

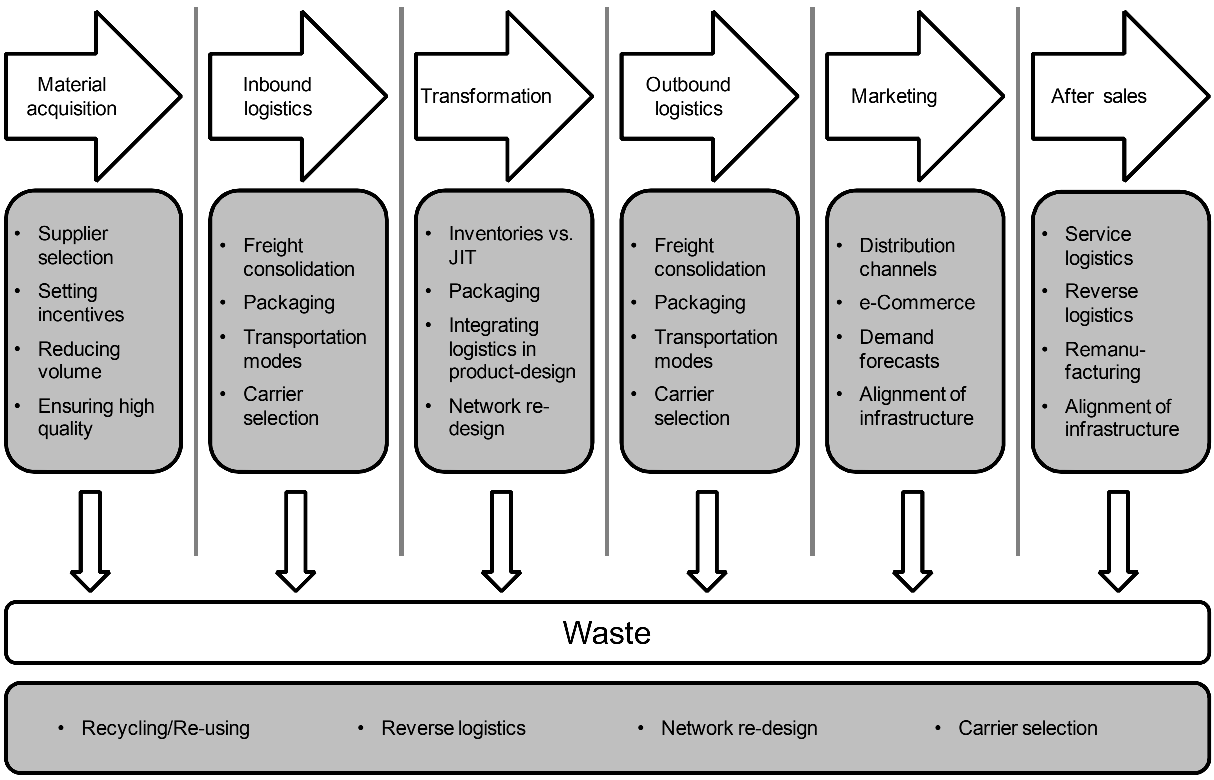


Figure 2: Reducing Environmental Impact in the Supply Chain.

In order to give an overview of the diverse opportunities to reduce environmental impact in logistics and the supply chain, we employ the framework displayed in figure 2. The figure shows a stylized supply chain model adapted from Wu & Dunn (1995). For each of the six phases of the chain (material acquisition -> after sales), we exemplarily included possibilities to reduce the environmental impact of the necessary logistics processes. For example for inbound as well as for outbound logistics, the consolidation of freight as well as the selected modes have decisive influence on the emission intensity of logistics (Aronsson & Brodin 2006). Choosing a transport mode like an ocean liner over air freight reduces emissions and costs per unit. If the density of product inside the container can be raised to fit more products into one unit, this also has positive effects on costs and emissions. Additionally, savings can be achieved through reduction of shipment frequencies by consolidating products to send larger shipments at a time. This can often be facilitated by collaborating with an external logistics provider who can provide economies of scale and density (Mello et al. 2008). Another important factor in transportation efficiency is the packaging. The reduction of packaging or the use of lighter or reusable packaging can reduce weight and waste during and after the transport. Just like the other presented opportunities aimed at creating lean and green logistics, this saves time and money (Mollenkopf et al. 2010). To make environmentally responsible decisions, the tradeoff between time and transport savings and information system investment for logistics costs should always be taken into account (Beamon 1999; Aronsson & Brodin 2006).

What is more, network design and process improvements hold vast opportunities to improve efficiency. Rather than just optimizing the performance within given structures and processes as the aforementioned approaches have as their goal, redesign of networks may provide ways to reduce or optimize logistical activity on a larger scale. For example sourcing raw materials locally (close to the manufacturing locations) can be an opportunity to cut back the necessary transports and thus save time, money and natural resources. In other words, employing environmental and logistical criteria in supplier selection can enable companies to optimize their network structure (Handfield et al. 2002). Another way of achieving higher efficiency in sourcing processes is the reduction of transport volume through minimization of scrap early in the chain. This saves cost and pollution simultaneously. Essential prerequisite is an efficient and correct process costing approach that gives detailed insight into the costs each process in logistics and manufacturing causes. This can enable the choice of vendors who assure environmental assessment of their processes and hereby ensure high resource quality. As selective materials are produced only in certain parts of the world the logistics network has to be reviewed regularly (Van Hoek 1999; Beamon 1999). Further opportunities to reinforce the global reach of sustainability driven network design in order to make logistics greener will be put forward in section 3.4.

Generally, emission reduction opportunities in logistics can be clustered into the two categories described above: redesigning the logistics network, sourcing and distribution on the one hand and optimizing the processes within a given structure on the other. It is however important to notice that when optimizing the network or the processes, a holistic view of costs and environmental impact is indispensable as the complexity of modern supply chains can lead to unexpected effects in other areas when changing one part of the system (Hofer & Knemeyer 2009; Milgate 2001). These unanticipated effects can easily overcompensate environmental benefits intended by the modification and should therefore be carefully monitored (Vannieuwenhuyse et al. 2003).

3.3. Compensation

As an addition to the effort of reducing environmental impact and making logistics greener, the pollution that cannot be avoided can be compensated. Several ways of compensation exist, however they all share the idea that unavoidable emissions can be offset by buying pollution credits on institutionalized markets or from certified projects. Because these credits use so called “carbon dioxide equivalents” (CO_2e) to represent all major GHG emissions converted into CO_2 (Foster et al. 2007), they are referred to as "carbon offsets" (DiPeso 2007). The money paid for these offsets is invested in a number of projects including renewable sources of energy, reforestation, development of new fuels, etc. Especially forestry has long been discussed as an effective way to offset GHG emissions although long term effects remain yet to be evaluated (Dixon et al. 1993).

Currently, two markets for carbon offsets exist, a larger compliance market (also referred to as the "allowance" market), as a result of international regulation and a smaller market for voluntary carbon offsets (Capoor & Ambrosi 2008). The compliance market is a direct result of the implemented caps for carbon emissions of national economies within the realms of the Kyoto Protocol and institutionalized by the European Union in their carbon emission trading scheme (EU ETS) (Hoen et al. 2010). The main reasoning behind establishing this market is the idea that the efficiency and thus costs of reducing carbon differs from one country and industry to another. The introduction of emission caps through the Kyoto Protocol has put pressure on heavy polluters to work towards the abatement of emissions. Within the trading schemes, companies and countries can now trade allowances for emissions in order to allocate investments for reduction efficiently. Research indicates that these markets have successfully established efficient resource allocation (e.g. Ashford et al. 2008; Capoor & Ambrosi 2008). However, other authors argue that the emerging market dynamics due to a flawed design of the Kyoto Protocol result in offerings of cheap abatement options for industrialized heavy polluting countries by the developing countries because they are not included in a meaningful way in the Protocol (Carbone et al. 2009). This compliance market is by design an environment dominated by political verve rather than direct business sense and the efficiency driven take on greener logistics of this manuscript does not lend itself well to the interpretation of sustainability simply as compliance. We acknowledge that compliance can be a driver for fostering efficiency as a way of proactively engaging future or pending legislation. However drawing on the aforementioned literature establishing sustainability in greener solutions as good business sense (e.g. Sowinski 2007; Srivastava 2007; Porter & Van der Linde 1995a, Porter & Van der Linde 1995b; Flint & Golicic 2009; Godfrey et al. 2008; Dwyer 2009; Markley & Davis 2007) we argue companies should be put in the driver seat to actively develop sustainability strategies rather than wait for the regulator to take the lead. While carbon offsets can provide an accessible way of approaching sustainability challenges they can only make minor contributions to the overall problem and do not eliminate the need for greener solutions i.e. the actual reduction of GHG emissions (DiPeso 2007). Offsets can be used to take care of emissions that just cannot be reduced but we strongly urge companies to tackle the challenge of becoming greener by cutting emissions using the approaches discussed in section 3.2. and treat carbon offsets only as an addition to their greener initiatives and employ them to round off their efforts.

3.4. Global Reach

A forth area has to be included into the suggested model in order to apply the discussed measures on a true global scale – as today too many greener logistics concepts are often applied only in specific areas (e.g. Europe) and do not apply to a whole (global) company or supply chain. This global reach dimension has two levels: First as indicated, companies and supply chains have to ensure that greener logistics concepts are implemented without geographical limits (and therefore indirectly including the social TBL perspective of globally 'fair' regimes). But second also a global strategic dimension has to be included into greener logistics concepts – for example by developing alternative transport systems in different regions of the globe aspiring for new transport alternatives as e.g. the rail connection between Asia and Europe. Moreover also strategic questions as for example a greener energy supply concept for global transport modes should be addressed on this global reach perspective.

4. SIMULATION AND FURTHER RESEARCH

The above outlined integrated concept for greener logistics could also provide a base for a quantitative approach towards an overall measurement of greener logistics activities enabling companies to benchmark their endeavours in this field. The calculation basis in terms of the outlines definition and measurement systems has to be identical (e.g. ISO 14064-1:2006 Greenhouse gases part 1, ISO 14064-2:2006 Greenhouse gases part 2, DIN EN 16258:2011 Methodology for calculation and declaration on energy consumptions and GHG emissions in transport services). Then we suggest that the three further areas of greener logistics measures (Reduction, Compensation and Global Reach) can be (i) measured in an index value normalized for a maximum value of 100 points and (ii) that the three areas can be combined as multiplication function towards a 'Total Greener Logistics Index Value (TGL)' as indicated in the figure below. This would lead to a maximum value of the TGL with 1,000,000 index points.

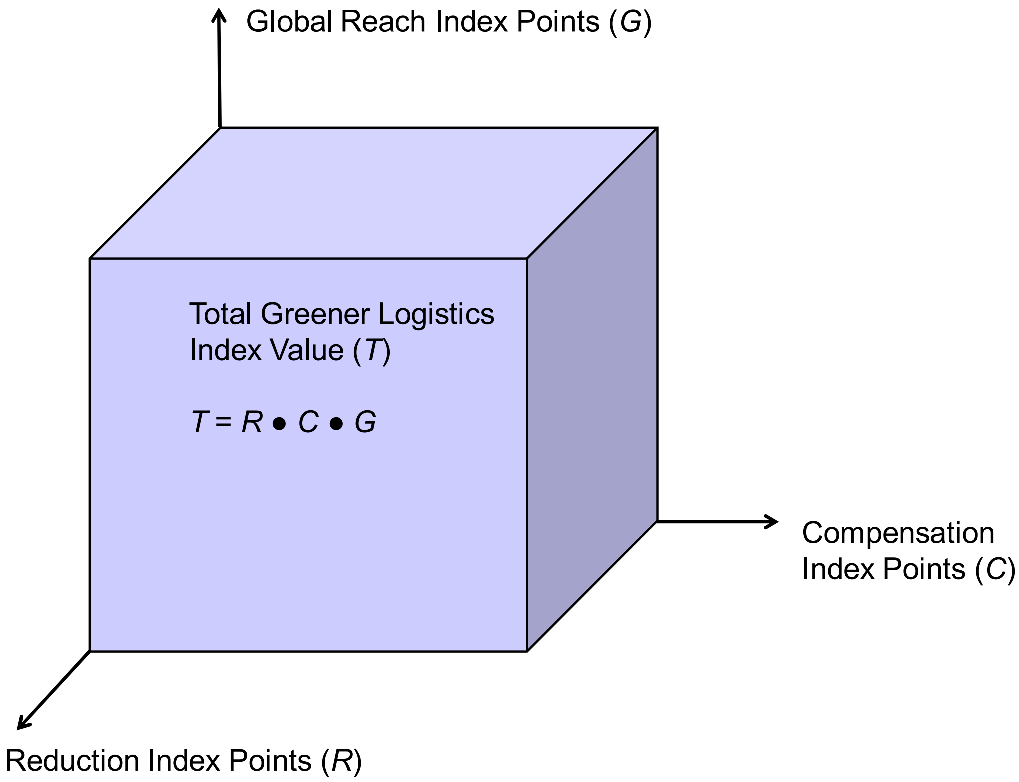


Figure 3: Total Greener Logistics Index Value Concept.

If any given company or supply chain would reach this maximum value this would indicate qualitatively that

a) first of all the technically possible reduction of environmental impact has been reached (technological production frontier, total resource efficiency per output parameter as e.g. ton-kilometre),
b) second, the environmentally negative influences left are compensated by matching measures to a full extend (zero total impact situation) and
c) third this is reached on a fully global scale for the whole company or supply chain (ubiquitous approach).

Therefore this total greener logistics index value could enable logistics companies to measure and compare their efforts in greener logistics in order to improve their position and indirectly also the overall logistics sustainability situation.

5. CONCLUSIONS

The total sustainability model outlined provides a basic concept and gives many greener logistics programs and concepts in companies and supply chains a theoretical and integrated basis as well as a possible overarching measurement option in the total greener logistics index value (TGL). Further research should strengthen this approach and address amongst others the following points:

- An increasing number of single measures and concepts regarding greener logistics could and should be linked to as well as integrated into the suggested TSM model.
- The suggested TGL value should be tested in practice by case study measurement research application with several pilot companies and supply chains.
- The proposed concept structure with four perspectives should be checked against other sustainability concepts as e.g. TBL and ISO in order to work towards a 'grand theory of sustainable logistics'.

Assuming these further research directions there may be a basis for high hopes that an integrated approach regarding sustainability in logistics may be possible and fruitful for research as well as business practice.

REFERENCES

Abukhader, S.M. & Jönson, G., 2004. Logistics and the environment: Is it an established subject? International Journal of Logistics: Research & Applications, 7(2), pp. 137-149.

Amundson, S.D., 1998. Relationships between theory-driven empirical research in operations management and other disciplines. Journal of Operations Management, 16(4), pp. 341-359.

Aronsson, H., Huge, Brodin, M., Kohn, C. (2008): Logistics Structures – Drivers of Environmental Impact. In: Stentoft, Arlbjørn, J., Halldórsen, Á., Jahre, M. et. Al. (Eds.) (2008): Northern Lights in Logistics & Supply Chain Management, Narayana Press: Gylling, p. 183-200.

Aronsson, H. & Brodin, M.H., 2006. The environmental impact of changing logistics structures. The International Journal of Logistics Management, 17(3), pp. 394-415.

Ashford, L. et al., 2008. Carbon offsetting trends survey 2008, EcoSecurities and ClimateBiz.

Atasu, A., Guide, V.D.R. & Van Wassenhove, L.N., 2008. Product Reuse Economics in Closed-Loop Supply Chain Research. Production and Operations Management, 17(5), pp. 483-496.

Bansal, P. & Hunter, T., 2003. Strategic Explanations for the Early Adoption of ISO 14001. Journal of Business Ethics, 46, pp. 289-299.

Baumgartner, R.J. & Ebner, D., 2010. Corporate sustainability strategies: sustainability profiles and maturity levels. Sustainable Development, 18(2), pp. 76-89.

Beamon, B., 1999. Designing the green supply chain. Logistics Information Management, 12(4), pp. 332-342.

Becker, T., 2008. Prozesse in Produktion und Supply Chain optimieren 2nd ed., Berlin, Heidelberg: Springer-Verlag.

Bekefi, T. & Epstein, M.J., 2008. Transforming Social and Environmental Risks into Opportunities. In IMA Annual Conference.

De La Torre, G., Karakaya, A., Goudz, A., Aldarrat, H., Noche, B. (2011): Elektromobilitätskonzept für KEP-Dienste, in: Jahrbuch Logistik 2011, p. 69-75.

DIN Deutsches Institut für Normung e.V. (2011): DIN EN 16258:2011, Methode zur Berechnung und Deklaration des Energieverbrauchs und Treibhausgasemissionen bei Transportdienstleistungen (Güter- und Personenverkehr), Entwurfsfassung, Beuth: Berlin.

de Burgos Jiménez, J. & Lorente, J.J.C., 2001. Environmental performance as an operations objective. International Journal of Operations & Production Management, 21(12), pp. 1553-1572.

Burson, P., 2008. Are you Green yet? Logistics Management (Highlands Ranch, Co.), 47(1), pp. 46-48.

Capoor, K. & Ambrosi, P., 2008. State and Trends of the Carbon Market 2008, Washington, DC: World Bank.

Carbone, J.C., Helm, C. & Rutherford, T.F., 2009. The case for international emission trade in the absence of cooperative climate policy. Journal of Environmental Economics and Management, 58(3), pp. 266-280.

Delmas, M., 2001. Stakeholders and Competitive Advantage: The Case of ISO 14001. Production and Operations Management, 10(3), pp. 343-358.

DiPeso, J., 2007. Carbon offsets: Is the environment getting what you pay for? Environmental Quality Management, 17(2), pp. 89-94.

Dixon, R.K. et al., 1993. Forest sector carbon offset projects: Near-term opportunities to mitigate greenhouse gas emissions. Water, Air, & Soil Pollution, 70(1-4), pp. 561-577.

Drake, M.J. & Ferguson, M.E., 2008. Closed-loop Supply Chain Management for Global Sustainability. Global Sustainability Initiatives: New Models and New Approaches. IAP.

Dwyer, R.J., 2009. "Keen to be green" organizations: a focused rules approach to accountability. Management Decision, 47(7), pp. 1200-1216.

Ehrenfeld, J.R., 2008. Sustainability by Design: A Subversive Strategy for Transforming Our Consumer Culture Grand Central P., Yale Univ Press.

Elkington, J., 1998. Partnerships from cannibals with forks: The triple bottom line of 21st-century business. Environmental Quality Management, 8(1), pp. 37-51.

Epstein, M.J. & Roy, M.-J., 2003. Making the business case for sustainability. Corporate Citizenship, (9), pp. 79-96.

Faber, N., Jorna, R. & Van Engelen, J., 2005. The Sustainability of "Sustainability" — A Study Into the Conceptual Foundations of the Notion of "Sustainability". Journal of Environmental Assessment Policy & Management, 7(1), pp. 1-33.

Ferguson, M.E. & Souza, G.C., 2010. Closed-Loop Supply Chains: New Developments to Improve the Sustainability of Business Practices 1st ed., Auerbach Publications.

Flapper, S.D.P., Van Nunen, J. & Van Wassenhove, L.N., 2005. Managing closed-loop supply chains, Springer.

Fleischmann, M., Nunen, J.A.E.E. van & Gräve, B., 2003. Integrating Closed-Loop Supply Chains and Spare-Parts Management at IBM. Interfaces, 33(6), pp. 44-56.

Flint, D.J. & Golicic, S.L., 2009. Searching for competitive advantage through sustainability: A qualitative study in the New Zealand wine industry. International Journal of Physical Distribution & Logistics Management, 39(10), pp. 841-860.

Foster, P. et al., 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In S. Solomon et al., eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Godfrey, P.C., Merril, C.B. & Hansen, J.M., 2008. The Relationsship Between Corporate Social Responsibility and Shareholdervalue: An Emperical Test of the Risk Management Hypothesis. Strategic Management Journal, (30), p. 425–445.

Handfield, R. et al., 2002. Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. European Journal of Operational Research, 141(1), pp. 70-87.

Hoen, K.M.R. et al., 2010. Effect of carbon emission regulations on transport mode selection in supply chains. in publishing. Available at:

http://alexandria.tue.nl/repository/books/672727.pdf.

Hofer, A.R. & Knemeyer, A.M., 2009. Controlling for logistics complexity: scale development and validation. The International Journal of Logistics Management, 20(2), pp. 187-200.

Huang, X.Y., Yan, N.N. & Qiu, R.Z., 2009. Dynamic models of closed-loop supply chain and robust H∞ control strategies. International Journal of Production Research, 47(9), pp. 2279-2300.

ISO (2006a): ISO 14064-1:2006, Greenhouse gases part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

ISO (2006b): ISO 14064-2:2006, Greenhouse gases part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.

Kersten, W. et al., 2010. Green Logistics: An Innovation for Logistics Products? In T. Blecker & W. Kersten, eds. Innovative Process Optimization Methods in Logistics. Operations and Technology Management. Berlin: ESV, pp. 369-386.

Lubin, D.A. & Esty, D.C., 2010. The Sustainability Imperative. Harvard Business Review, 88(5), pp. 42-50.

Markley, M.J. & Davis, L., 2007. Exploring future competitive advantage through sustainable supply chains. International Journal of Physical Distribution & Logistics Management, 37(9), pp. 763-774.

McKinnon, A., 2007. CO2 Emissions from Freight Transport in the UK, Logistics Research Centre Heriot-Watt University Edinburgh.

Mello, J.E., Stank, T.P. & Esper, T.L., 2008. A Model of Logistics Outsourcing Strategy. Transportation Journal, 47(4), pp. 5-25.

Milgate, M., 2001. Supply chain complexity and delivery performance: an international exploratory study. Supply Chain Management: An International Journal, 6(3), pp. 106-118.

Mollenkopf, D. et al., 2010. Green, lean, and global supply chains. International Journal of Physical Distribution & Logistics Management, 40(1/2), pp. 14-41.

Morana, R. & Seuring, S., 2007. End-of-life returns of long-lived products from end customer - insights from an ideally set up closed-loop supply chain. International Journal of Production Research, 45(18/19), pp. 4423-4437.

Norman, W. & MacDonald, C., 2004. Getting to the Bottom of "Triple Bottom Line." Business Ethics Quarterly, 14(2), pp. 243-262.

Ohno, T., 1988. Toyota Production System: Beyond Large-Scale Production 1st ed., Productivity Press.

Pawellek, G., O'shea, M., Schramm, A. (2011): Logistikgerechte Produktentwicklung – simultanes Gewichts- und Kostencontrolling zur Verbesserung der CO_2-Bilanz, in: Jahrbuch Logistik 2011, p. 20-24.

Polonski, M. J. (2001): Green Marketing. In: Charter, M., Tischner, U. (2001): Sustainable Solutions – Developing Products and Services for the future, Greenleaf: Sheffield, p. 282-303.

Porter, M.E. & Van der Linde, C., 1995a. Green and Competitive: Ending the Stalemate. Harvard Business Review.

Porter, M.E. & Van der Linde, C., 1995b. Toward a new conception of the environment-competitiveness relationship. The Journal of Economic Perspectives, 9(4), pp. 97-118.

Rondinelli, D. & Vastag, G., 2000. Panacea, common sense, or just a label?:: The value of ISO 14001 environmental management systems. European Management Journal, 18(5), p. 499.

Scholz, C. (2011): Grüner Innovations-Druck treibt die Logistik-Branche, in: Jahrbuch Logistik 2011, p. 136-139.

Sowinski, L.L., 2007. Green Is Going Mainstream - Transportation and logistics are embracing environmentalism as a way to cut costs and enhance their image. World Trade Magazine, pp. 16-22.

Srivastava, S.K., 2007. Green Supply-Chain Management: A State-of-the-art Literature Review. International Journal of Management Reviews, 9(1), p. 53–80.

Stavins, R.N., Wagner, A.F. & Wagner, G., 2003. Interpreting sustainability in economic terms: dynamic efficiency plus intergenerational equity. Economics Letters, 79(3), pp. 339-343.

Sundarakani, B., de Souza, R., Goh, M. et al. (2010): A Sustainable Green Supply Chain for Globally Integrated Network. In: Wang, L., Koh, S.C, (Eds.): Enterprise Networks and Logistics for Agile Manufacturing, Springer: London, p. 191-206.

Van Hoek, R.I., 1999. From reverse logistics to green supply chains. Supply Chain Management: An International Journal, 4(3), pp. 129-134.

Vannieuwenhuyse, B., Gelders, L. & Pintelon, L., 2003. An online decision support system for transportation mode choice. Logistics Information Management, 16(2), pp. 125-133.

Veleva, V. et al., 2001. Indicators of sustainable production. Journal of Cleaner Production, 9(5), pp. 447-452.

WCED, 1987. Our Common Future, Report of the World Commission on Environment and Development.

Westlund, A.H., 2001. Measuring environmental impact on society in the EFQM system. Total Quality Management, 12(1), pp. 125-135.

Wolf, C. & Seuring, S., 2010. Environmental impacts as buying criteria for third party logistical services. International Journal of Physical Distribution & Logistics Management, 40(1/2), pp. 84-102.

World Resources Institute, 2004. A Corporate Accounting and Reporting Standard, Washington, DC.

World Resources Institute, 2009. Scope 3 Accounting and Reporting Standard.

Wu, H.-J. & Dunn, S.C., 1995. Environmentally responsible logistics systems. International Journal of Physical Distribution & Logistics Management, 25(2), pp. 20-38.

TRENDS IN THE ENVIRONMENTAL IMPACT OF LOGISTICS SECTOR COMPANIES AND AN EXAMINATION OF THE LIKELY IMPACT OF REVISIONS TO THE "LAW CONCERNING THE RATIONAL USE OF ENERGY"

Yuji Yano, Etsuo Masuda, GyeongHwa Hong
Ryutsu Keizai University.

1. INTRODUCTION

The "Law Concerning the Rational Use of Energy" was adopted in 1979, as a way to promote energy conservation in Japan. The original law dealt mainly with the rationalization of energy use by factories, as part of the production process. It was amended in 2005 to extend the effort to rationalize energy use to cover the transportation sector as well. The revisions made it compulsory for all companies in the transport sector (those that own large numbers of delivery vehicles), as well as all major shippers (those that handle a large volume of merchandise that needs to be shipped) to submit regular reports on their plans to control and reduce energy consumption. It also demanded that these companies make strenuous efforts to reduce energy consumption per unit of business transacted by a minimum of 1% per year.

This research study will seek to quantify and analyze trends in energy use and environmental impact for companies in the logistics sector, as it relates to the revised "Law Concerning the Rational Use of Energy". Specifically, it will try to clarify characteristics and trends in energy use for each industry and each major company. Based on this analysis, the study will quantify the declining trend in CO_2 emissions by the logistics sector between fiscal year 2006 and fiscal 2008. It will consider what portion of this decline is attributable to the general drop in transport volume caused by the global economic slump, and what portion is attributable to the energy-saving efforts of transport companies, in an effort to clarify the CO_2 emissions trends for each industry sector and each major transport company. In addition, it will provide a summary of the implementation status and relative results of various plans to reduce environmental impact.

2. OVERVIEW OF REVISED VERSION OF LAW CONCERNING THE RATIONAL USE OF ENERGY

2.1. Specified Carrier

Under the "Law Concerning the Rational Use of Energy", business entities that each have a transport capacity equal to or exceeding the criterion (300 railcars for a railroad company, 200 freight vehicles, and the gross tonnage of 20,000 [t] as the freight space for a shipping company) shall be designated as "specified carriers" (for each transportation). The specified carriers are obligated to formulate their energy-saving plans and submit regular reports, etc., on items such as the amount of energy they use. The term "carriers" used herein means carriers including not only freight forwarders forwarding as their businesses but also companies that use their own freight cars.

(1) Formulation of Long- and Middle-Term Plans
Each specified carrier shall submit a plan for each fiscal year on its long- and middle-term energy-saving measures and shall describe the energy-saving effects which are expected based on each of the measures.

(2) Regular Reporting
Each specified carrier shall report for each fiscal year on items such as the amount of energy it has used, the status of its energy use (such as energy use efficiency), and the implementation status of its energy-saving measures. It is provided in The law that the energy consumption basic unit which is used as the index for Energy saving is "(energy consumption)/(ton-kilometers carried)".

2.2. Specified Shipper

Companies that each handle a total of 30 million [ton-kilometer] or more as its freight to transport shall be designated as "specified shippers" and are obligated to formulate the plan and regularly report.

(1) Formulation of Plans
Each specified shipper is obligated to prepare a "plan" in writing and submit it to the relevant minister once a year. Each specified shipper shall select efforts that the shipper can implement according to the company's decision, and formulate and submit the plan for the efforts.

(2) Regular Reporting
Each specified shipper is obliged to report to the relevant minister once a year on the following items.
・The amount of energy used for its transport
・The energy use basic unit: (The amount of energy used for transport)/(the value that closely relates to the amount of energy used for the transport (such as the amount of freight transported [ton-kilometer], the weight of the freight, the sales, or the cost for the transportation, selected by each company based on the status of the company))
・The implementation status of the energy-saving steps
・Items such as the amount of carbon dioxide emitted associated with the use of energy
When it is admitted that the efforts for energy saving are remarkably insufficient, such a step may be taken as advising, announcement to the public, a legal order, or a fine of one million Japanese yen or lower.

2.3. Overview of Specified Shipper

The specified shippers are 871 companies in the fiscal 2008.
According to the breakdown of the amount of freight transported by the 865 companies which were designated as the specified shippers as of the end of June 2008: 494 companies (about 57%) each transported less than 100 million [ton-kilometer]; 144 companies (about 17%) each transported 100 to 200 million [ton-kilometer]; and 45 companies (about 5%) each transported 1,000 million or more [ton-kilometer].

As the characteristic concerning the industry sector, manufacturing companies were dominating and were 670 companies accounting for 76.9%. According to the breakdown thereof: chemical companies were 124; food production and processing companies were 91; iron and steel companies were 66; ceramics, earthenware, and stoneware companies were 65; transportation machinery and tool manufacturing companies were 58; beverage, tobacco, and feed producing companies were 48; pulp, paper, and paper product manufacturing companies were 39; plastic product manufacturing companies were 29; non-ferrous metal product manufacturing companies were 24; and electric machinery and tool manufacturing companies were 22. Following these, the wholesaling industry and the retailing industry included 140 companies and accounted for 16.1%. According to the breakdown there of wholesaling companies of construction materials and mineral and metal materials, etc., were 43; wholesaling companies of food and beverages were 29; and wholesaling companies of various kinds of merchandise were 23.

3. CHANGES IN CO_2 EMISSION RELATED TO LOGISTICS SECTOR

3.1. Overview of Total CO2 Emission Related to Logistics Sector

The total CO_2 emission related to the logistics sector in Japan is clarified as shown in Fig. 1. The emission was 105.31 [tCO_2] in 1990. The emission continued to increase afterward until 1996 and reached 116.28 [tCO_2] in 1996 showing an increase by 10.4% compared to that in 1990. In 1996 as a turning point, the total CO_2 emission related to logistics sector started to decrease and maintained this trend afterward. The emission was 102.12 [tCO_2] in 2002 showing a decrease compared to that in 1990 and became less than 100 million [tCO_2] in 2005. The emission reached 0.913 million [tCO_2] in 2008 showing a decrease by 13.3% compared to that in 1990 and also showing a decrease by 21.5% compared to that in 1996 when the emission reached its maximum. According to the CO_2 emission by transportation, each of all kinds of transportation reduced its emission in 2008 compared to that in 1996 and, especially, the CO_2 emission of private freight vehicles remarkably decreased and showed a decrease by 31.6%. The main reason for this decrease was the shift from the private freight vehicles to business-use freight vehicles that presented higher transportation efficiency for transporting the freight. The total CO_2 emission of the freight vehicles including private ones and business-use ones showed a decrease in 2008 by 21.7% compared to that in 1996.

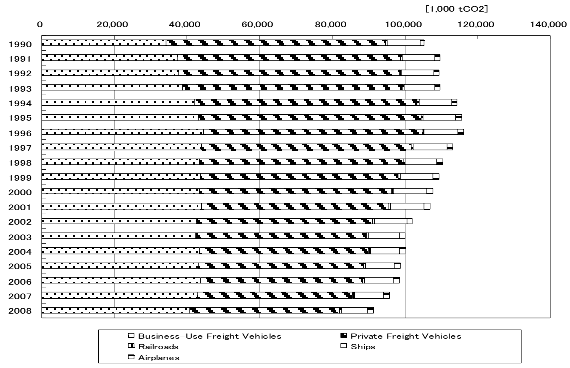


Fig. 1: Changes in CO_2 Emission Related to Logistics Sector
Source: Produced based on reference materials from the National Institute for Environmental Studies (Japan)

3.2. Overview of CO_2 Emission Related to Physical Distribution Sector under Revised Version of "Law Concerning the Rational Use of Energy"

The changes in the CO_2 emission of the specified freight carriers and the specified shippers under the revised version of the "Law Concerning the Rational Use of Energy" were as shown in Fig. 2. The emission of the specified freight carriers was 11.7 million [tCO_2] in the fiscal 2008 and maintained a downward trend decreasing to 12.81 million [tCO_2] in the fiscal 2006 and 12.47 million [tCO_2] in the fiscal 2007. The emission showed a decrease by 8.6% from the fiscal 2006 to the fiscal 2008. The emission of the specified shippers was 16.88 million [tCO_2] in the fiscal 2008 and showed a downward trend following their emission of 19.29 million [tCO_2] in the fiscal 2006 and 18.64 million [tCO_2] in the fiscal 2007. The emission showed a decrease by 12.5% from the fiscal 2006 to the fiscal 2008. As above, both of them showed the large decreases. The decrease of the amount of freight due to the economic slowdown was the most important factor of the decreases. However, the advancement of the environmental measures taken by the companies was also strongly influenced the decreases.

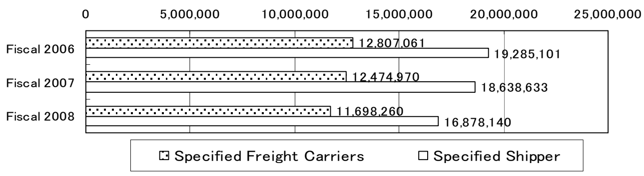


Fig. 2: Changes in CO_2 Emission Related to Physical Distribution Sector under Revised Version of "Law Concerning the Rational Use of Energy" [tCO_2]

4. CO_2 EMISSIONS OF SPECIFIED FREIGHT CARRIERS AND SPECIFIED SHIPPERS

4.1. CO_2 Emission of Specified Freight Carriers

The CO_2 emission of the specified freight carriers was 11.7 million [tCO_2] in the fiscal 2008. The transportation industry and the postal service accounted for an overwhelmingly large portion of this emission and emitted 11.25 million [tCO_2] accounting for 96.1%. According to the breakdown, the road transport industry accounted emitted 5.88 million [tCO_2] accounting for 50.2% and the water transport industry emitted 4.69 million [tCO_2] accounting for 40.1%. As above, as to the specified freight carriers, the CO_2 emissions of companies running forwarding businesses accounted for an overwhelmingly large portion of the CO_2 emission and a very small portion of the CO_2 emissions was shared by the companies such as manufacturing companies, wholesalers, retailers, etc., that used their own freight vehicles. The CO_2 emission per company was 28,189 [tCO_2] as the general average.

4.2. CO_2 Emission of Specified Shippers

The CO_2 emission of the specified shippers was 16.88 million [tCO_2] in the fiscal 2008. As the characteristic concerning kinds of industry, the manufacturing industry sector presented the largest emission of 13.03 million [tCO_2] accounting for 77.6%. According to the breakdown of this emission, following the above: the emission of the food production and processing industry was 2.21 million [tCO_2] accounting for 13.1%; that of the iron and steel industry was 2.02 million [tCO_2] accounting for 12.06%; that of the chemical industry was 1.82 million [tCO_2] accounting for 10.8%; that of the transportation machinery and tool manufacturing industry was 1.14 million [tCO_2] accounting for 6.8%; that of the ceramics, earthenware, and stoneware manufacturing industry was 1.04 million [tCO_2] accounting for 6.1%; that of the pulp, paper, and paper product manufacturing industry was 1.03 million [tCO_2] accounting for 6.1%; and that of the beverage, tobacco, and feed producing industry was 0.92 million [tCO_2] accounting for 5.5%. These emissions were followed by that of the wholesaling industry and the retailing industry posting 2.55 million [tCO_2] and accounting for 15.1%. According to the breakdown: the emission of the wholesaling industry for construction materials and mineral and metal materials was 0.96 million [tCO_2] accounting for 5.7%; that of the wholesaling industry for food and beverages was 0.63 million [tCO_2] accounting for 3.7%; and that of the wholesaling industry for various kinds of merchandise was 0.36 million [tCO_2] accounting for 2.2%.

Table 1: Number of Companies by Industry and CO_2 Emission of Specified Freight Carriers and Specified Shippers (Fiscal 2008)

	Number of Business Establishments				CO2 Emission				CO2 Emission per Company	
	Specified Fright Carrier		Specified Shipper		Specified Fright Carrier		Specified Shipper		Specified Fright Carrier	Specified Shipper
		%		%	tCO_2	%	tCO_2	%		
Total	415	100.0%	871	100.0%	11,698,260	100.0%	16,878,140	100.0%	28,189	19,378
Mining, Quarrying, and Gravel Collecting Industries	1	0.2%	13	1.5%	5,940	0.1%	144,924	0.9%	5,940	11,148
Construction Industry			10	1.1%			171,360	1.0%		17,136
Manufacturing Industry	16	3.9%	670	76.9%	138,827	1.2%	13,025,596	77.2%	8,677	19,441
Food Producing Industry	8	1.9%	91	10.4%	93,280	0.8%	2,211,004	13.1%	11,660	24,297
Beverage, Tobacco, and Feed Producing Industry	5	1.2%	48	5.5%	36,837	0.3%	922,121	5.5%	7,367	19,211
Textile Industry			6	0.7%			92,720	0.5%		15,453
Wood and Wooden Product Manufacturing Industry			13	1.5%			97,713	0.6%		7,516
Furniture and Fixtures Manufacturing Industry			5	0.6%			65,070	0.4%		13,014
Pulp, Paper, and Paper Product Manufacturing Industry			39	4.5%			1,029,867	6.1%		26,407
Printing and Related Industries			6	0.7%			70,680	0.4%		11,780
Chemical Industry			124	14.2%			1,823,003	10.8%		14,702
Petroleum Product and Coal Product Manufacturing Industry			12	1.4%			642,860	3.8%		53,572
Plastic Product Manufacturing Industry			29	3.3%			286,686	1.7%		9,886
Rubber Product Manufacturing Industry			5	0.6%			156,729	0.9%		31,346
Ceramics, Earthenware, and Stoneware Manufacturing			65	7.5%			1,037,794	6.1%		15,966
Iron and Steel Industry			66	7.6%			2,018,091	12.0%		30,577
Non-Ferrous Metal Manufacturing Industry			24	2.8%			251,356	1.5%		10,473
Metal Product Manufacturing Industry	1	0.2%	17	2.0%	4,940	0.0%	268,135	1.6%	4,940	15,773
General-Purpose Machinery and Tool Manufacturing			8	0.9%			117,623	0.7%		14,703
Production Machinery and Tool Manufacturing Industry	2	0.5%	10	1.1%	3,770	0.0%	106,118	0.6%	1,885	10,612
Business-Use Machinery and Tool Manufacturing Industry			8	0.9%			98,110	0.6%		12,264
Electronic Part, Device, and Circuit Manufacturing Industry			2	0.2%			11,223	0.1%		5,612
Electric Machinery and Tool Manufacturing Industry			22	2.5%			435,453	2.6%		19,793
Information and Communication Machinery and Tool Manufacturing Industry			4	0.5%			54,954	0.3%		13,739
Transportation Machinery and Tool Manufacturing Industry			58	6.7%			1,142,976	6.8%		19,706
Other Manufacturing Industries			8	0.9%			85,310	0.5%		10,664
Electricity, Gas, Heat Supply, and City Water Industries	1	0.2%	18	2.1%	611	0.0%	199,112	1.2%	611	11,062
Electricity Industry			16	1.8%			188,802	1.1%		11,800
Gas Industry			2	0.2%			10,310	0.1%		5,155
City Water Industry					611	0.0%				
Information and Communication Industry			1	0.1%			13,600	0.1%		13,600
Transportation and Postal Service Industries	319	76.9%	4	0.5%	11,247,627	96.1%	231,350	1.4%	35,259	57,838
Railroad Industry	1	0.2%			666,000	5.7%			666,000	
Railroad Freight Forwarding Industry	283	68.2%	1	0.1%	5,876,637	50.2%	7,840	0.0%	20,766	7,840
Water Transport Industry	34	8.2%	1	0.1%	4,686,900	40.1%	3,210	0.0%	137,850	3,210
Industry for Services Accompanying Transportation	1	0.2%	2	0.2%	13,900	0.1%	220,300	1.3%	13,900	110,150
Postal Service Industry	1	0.2%			4,190	0.0%			4,190	
Wholesaling and Retailing Industries	56	13.5%	140	16.1%	208,680	1.8%	2,551,718	15.1%	3,726	18,227
Wholesaling Industry for Various Kinds of Merchandise	1	0.2%	23	2.6%	1,610	0.0%	363,775	2.2%	1,610	15,816
Wholesaling Industry for Textile, Clothing, etc.	2	0.5%			4,114	0.0%			2,057	
Wholesaling Industry for Food and Beverages	17	4.1%	29	3.3%	64,730	0.6%	625,263	3.7%	3,808	21,561
Wholesaling Industry for Construction Materials, Mineral and Metal Materials	2	0.5%	43	4.9%	9,740	0.1%	961,224	5.7%	4,870	22,354
Wholesaling Industry for Machinery and Tools	8	1.9%	3	0.3%	30,140	0.3%	27,840	0.2%	3,768	9,280
Wholesaling Industry for Other Items	12	2.9%	15	1.7%	47,358	0.4%	244,297	1.4%	3,947	16,286
63 Retailing Industry for Various Kinds of Merchandise	2	0.5%	12	1.4%	4,260	0.0%	155,989	0.9%	2,130	12,999
Retailing Industry for Textile, Clothing, and Small Daily-Use Articles	3	0.7%	2	0.2%	6,360	0.1%	19,190	0.1%	2,120	9,595
Retailing Industry for Food and Beverages	5	1.2%	3	0.3%	31,496	0.3%	38,210	0.2%	6,299	12,737
Retailing Industry for Machinery and Tools	1	0.2%	1	0.1%	4,620	0.0%	7,300	0.0%	4,620	7,300
Retailing Industry for Other Articles	2	0.5%	8	0.9%	3,260	0.0%	104,840	0.6%	1,630	13,105
Non-Store Retailing Industry	1	0.2%	1	0.1%	992	0.0%	3,790	0.0%	992	3,790
Real Estate Industry and Rental Service Industry	2	0.5%			26,190	0.2%			13,095	
Hotel Industry and Restaurant Industry			4	0.5%			52,120	0.3%		13,030
Restaurants			3	0.3%			45,760	0.3%		15,253
Take-Out and Delivery Food Industry			1	0.1%			6,360	0.0%		6,360
Daily-Living-Related Service Industry and Entertainment Industry	5	1.2%			17,840	0.2%			3,568	
Laundry, Hair Dressing, and Public Bath Industries	1	0.2%			4,130	0.0%			4,130	
Other Daily-Living-Related Industries	4	1.0%			13,710	0.1%			3,428	
Education and Learning Aid Industry	2	0.5%	1	0.1%	4,280	0.0%	10,800	0.1%	2,140	10,800
Medical and Welfare Industries	2	0.5%			15,700	0.1%			7,850	
Complex Service Businesses	8	1.9%	4	0.5%	17,795	0.2%	367,350	2.2%	2,224	91,838
Service Industry	1	0.2%	5	0.6%	3,080	0.0%	100,420	0.6%	3,080	20,084
Waste Disposal Industry			2	0.2%			15,320	0.1%		7,660
Industry for Other Commercial Services	1	0.2%	1	0.1%	3,080	0.0%	56,000	0.3%	3,080	56,000
Other Service Industries			2	0.2%			29,100	0.2%		14,550
Public Services	2	0.5%	1	0.1%	11,690	0.1%	9,790	0.1%	5,845	9,790

Source: Produced based on "Result of Totaling the Greenhouse Effect Gas Emissions Based on the Law Concerning the Promotion of the Measures to Cope with Global Warming" by the Global Warming Measure Section, the Global Environment Bureau, the Ministry of the Environment and the Environmental Economy Office, the Industrial Science and Technology and Environment Bureau, the Ministry of Economy, Trade and Industry

As to the CO_2 emission per company, the average in CO_2 emission per company in all the industries was 19,378 [CO_2]. The CO_2 emission per company was 19,441 [tCO_2] in the manufacturing industry and 18,227 [tCO_2] in the wholesaling and retailing industries. As to the CO_2 emission per company by field of the manufacturing industry in detail: the emission per company in the petroleum product and coal product manufacturing industry was 53,572 [tCO_2] and was the largest one; the emission per company in the rubber product manufacturing industry was 31,346 [tCO_2]; the emission per company in the iron and steel industry was 30,577 [tCO_2]; and the emission per company in the pulp, paper, and paper product manufacturing industry was 26,407 [tCO_2]. The emission per company in each of these three industries was also large. On the other hand, the emission per company in the electronic part, device, and circuit manufacturing industry was 5,612 [tCO_2] and was the smallest. The emission per company in the wood and wooden product manufacturing industry was 7,516 [tCO_2] and was also small. In the wholesaling and retailing industry sector, the emission per company in the wholesaling industry for construction materials and mineral and metal materials was 22,354 [tCO_2] and was the largest one. The emission per company in the wholesaling industry for food and beverages was 21,561 [tCO_2] and was also large.

5. CO_2 EMISSION BY SPECIFIED FREIGHT CARRIERS BY COMPANY

5.1. CO_2 Emission by Specified Freight Carriers

According to the distribution of the CO_2 emission by company in 2008: the number of the companies each having emitted 10,000 [t] or more and less than 50,000 [t] was the largest and was 160 accounting for 38.6%; following this, the number of the companies each having emitted 1,000 [t] or more and less than 5,000 [t] was 107 accounting for 25.8%; and the number of the companies each having emitted 5,000 [t] or more and less than 10,000 [t] was 92 accounting for 22.2%. The number of the companies each having emitted 100,000 [t] or more was 26 and the number of the companies each having emitted 50,000 [t] or more and less than 100,000 [t] was 25. On the other hand, the number of companies each having emitted less than 1,000 [t] was only five.

5.2. Increase/Decrease Rate of CO_2 Emission by Specified Freight Carrier

The CO_2 emission will be clarified by specific freight carrier. Fig. 3 shows the clarified percentages of the number of companies by increase/decrease rate in terms from 2006 to 2007, 2007 to 2008, and 2006 to 2008. As to the term from 2006 to 2008, the number of companies whose CO_2 emissions in 2008 were 0.8 to 0.9 times as much as those in 2006 was the largest and these companies accounted for 21.0%; and the companies whose CO_2 emissions in 2008 were 0.9 to 0.95 times as much as those in 2006 accounted for 20.2%. In contrast: the companies whose CO_2 emissions increased compared to those in 2006 and were 1.1 times as much as or more than those in 2006 accounted for 14.5%; and the companies whose CO_2 emissions were 1.0 to 1.1 times as much as those in 2006 accounted for 17.2% and, therefore, the number of these companies was larger than that of the specified shippers. There was a significant difference in the trend of the increases and the decreases between the terms from 2006 to 2007 and from 2007 to 2008. As to the term from 2006 to 2007, the companies with the rates of 0.95 to 1.0 were most dominating and accounted for 33.6% and the companies whose emissions increased with the rates of 1.0 to 1.1 accounted for 33.3% and were also dominating. As to the term from 2007 to 2008, the companies with the rates of 0.95 to 1.0 accounted for 28.2% and were most dominating. However, following these, the companies with the rates of 0.9 to 0.95 accounted for 24.5%. The reasons why more companies reduced their emissions in the term from 2007 to 2008 than those in the term from 2006 to 2007 were: the influence of the economy; and the advancement of the eco-driving, introduction of low-emission vehicles, etc.

Table 2 shows the clarified increase/decrease rates of CO_2 emissions in the term from 2006 to 2008 for the content of each business. As to the business-use cars, the companies whose CO_2 emissions in 2008 were less than 0.9 times as much as those in 2006 and which presented a large decrease rates accounted for 36.4% and were dominating. In contrast, as to the private cars, the companies whose CO_2 emission increased in the term from 2006 to 2008 with the rates of 1.0 or higher accounted for 45.8% and were also dominating. As above, as to the CO_2 emissions in the term from 2006 to 2008, the percentage of the companies whose emissions significantly decreased was high for the business-use cars.

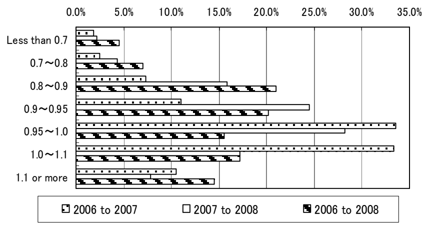


Fig. 3: Increase/Decrease Rate of CO_2 Emission by Specified Freight Carrier

Table 2: Increase/Decrease Rate of CO_2 Emission from 2006 to 2008 by Content of Business

Content of Business	Less than 0.7	0.7-0.8	0.8-0.9	0.9-0.95	0.95-1.0	0.1-1.1	1.1 or higher	Total
Business-Use Car	12	19	63	54	36	40	34	258
	4.7%	7.4%	24.4%	20.9%	14.0%	15.5%	13.2%	100.0%
Private Car	4	5	8	13	15	21	17	83
	4.8%	6.0%	9.6%	15.7%	18.1%	25.3%	20.5%	100.0%
Marine Transportation	1	2	7	7	7	3	3	30
	3.3%	6.7%	23.3%	23.3%	23.3%	10.0%	10.0%	100.0%
Railroad				1				1
	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%
Total	17	26	78	75	58	64	54	372
	4.6%	7.0%	21.0%	20.2%	15.6%	17.2%	14.5%	100.0%

6. CO_2 EMISSION OF SPECIFIED SHIPPERS BY COMPANY

6.1. CO_2 Emissions of Specified Shippers

According to the distribution of the emission in the fiscal 2008 by company: the companies whose emissions were each 10,000 [t] or more and less than 50,000 [t] were the most and were 311 companies accounting for 35.7%; following this, the companies whose emissions were each 5,000 [t] or more and less than 10,000 [t] were 279 companies accounting for 32.0%; and the companies whose emissions were each 1,000 [t] or more and less than 5,000 [t] were 216 companies accounting for 24.8%. The companies who each emitted 100,000 [t] or more were 26 companies and the companies who each emitted 50,000 [t] or more and less than 100,000 [t] were 36 companies and, therefore, such companies were reduced in its number. On the other hand, the companies whose emissions were each less than 1,000 [t] were only three.

The result of calculation of the relation between the percentage of the number of companies and the accumulated percentage of the emissions shows that the top 10 largest-emission companies accounted for 18.7% and the top 50 large-emission companies accounted for 42.4% of the total emission emitted from the 871 companies that are subject to the revised version of the Law Concerning the Rational Use of Energy. The calculation resulted in providing the fact that the accumulated emissions of 76 companies accounted for 50% and that of 317 companies accounted for 80%. As above, the emission significantly differed among companies and the percentage accounted for by the companies with large emissions was high.

6.2. Increase/Decrease Rate of CO_2 Emission of Specified Shipper by Company

Fig. 4 shows the clarified percentages of the number of companies by increase/decrease rate in the terms from 2006 to 2007, 2007 to 2008, and 2006 to 2008. As to the term from 2006 to 2008, the companies whose CO_2 emissions in 2008 were 0.8 to 0.9 times as much as those of 2006 were most dominating and accounted for 25.6%; and the companies whose CO_2 emissions in 2008 were 0.7 to 0.8 times as much as those in 2006 accounted for 19.1%. In contrast: the companies whose CO_2 emissions increased compared to those in 2006 and were 1.1 times as much as or more than those of 2006 accounted for 11.1%; and the companies whose CO_2 emissions were 1.0 to 1.1 times as much as those in 2006 accounted for 9.8%. However, there was a significant difference in the trend of the increases and the decreases between the terms from 2006 to 2007 and from 2007 to 2008. As to the term from 2006 to 2007, the companies whose emissions increased at the rates of 1.0 to 1.1 were most dominating and accounted for 26.1%. Following these, the companies with the rates of 0.95 to 1.0 accounted for 22.8%. On the other hand, as to the term from 2007 to 2008, the companies with the rates of 0.8 to 0.9 accounted for 33.0% and were most dominating. Two aspects which are the influence of the economy and the prevalence of the measures for reducing the CO_2 emissions can be considered to be the reasons why many companies significantly reduced their emissions in the term from 2007 to 2008.

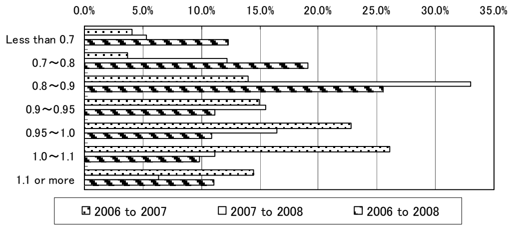


Fig. 4: Increase/Decrease Rate of CO_2 Emission of Specified Shipper by Company

Table 3 shows the clarified increase/decrease rates of CO_2 emissions in the term from 2006 to 2008 by industry. The increase/decrease rate differs among the industries. Industries each including many companies whose CO_2 emissions in 2008 presented high decrease rates of less than 0.8 compared to its CO2 emission in 2006 were: other manufacturing industries 50% of which were such companies; following these, the wood-based manufacturing industry 47.0% of which were such companies; the machinery-based manufacturing industry 44.7% of which were such companies; and the construction industry 44.4% of which were such companies. The industries each including companies with the rates of less than 0.9 were: the wood-based manufacturing industry 88.2% of which were such companies; other manufacturing industries 87.5% of which were such companies; the textile industry 83.3% of which were such companies; the machinery manufacturing industry 73.3% of which were such companies; and the metal-based manufacturing industry 72.5% of which were such companies. Therefore, as the current status, most of the companies had achieved. On the other hand, industries each including many companies whose CO_2 emissions increased from 2006 to 2008 with the rates of 1.0 or more were: the retailing industry 70.0% of which were such companies; other industries such as the service industry, 50.0% of which were such companies; the electricity, gas, and city water industries 43.8% of which were such companies; and the manufacturing industry for beverages, etc., 40.9% of which were such companies. The wholesaling industry also included relatively many such companies that accounted for 27.4%.

Table 3: Increase/Decrease Rate of CO_2 Emission from 2006 to 2008 by Industry

Industry	Less than 0.7	0.7～0.8	0.8～0.9	0.9～0.95	0.95～1.0	1.0～1.1	1.1 or more	Total
Mining Industry	3	1	2	2	3	1		12
	25.0%	8.3%	16.7%	16.7%	25.0%	8.3%	0.0%	100.0%
Construction Industry	2	2	2	1		2		9
	22.2%	22.2%	22.2%	11.1%	0.0%	22.2%	0.0%	100.0%
Food Producing Industry	5	7	18	15	19	13	4	81
	6.2%	8.6%	22.2%	18.5%	23.5%	16.0%	4.9%	100.0%
Manufacturing Industry for Beverages, etc.	3	7	6	4	6	5	13	44
	6.8%	15.9%	13.6%	9.1%	13.6%	11.4%	29.5%	100.0%
Textile Industry	1	1	3		1			6
	16.7%	16.7%	50.0%	0.0%	16.7%	0.0%	0.0%	100.0%
Wood-Based Manufacturing Industry	4	4	7		1	1		17
	23.5%	23.5%	41.2%	0.0%	5.9%	5.9%	0.0%	100.0%
Pulp and Paper-Based Manufacturing Industry	2	5	5	9	7	6	5	39
	5.1%	12.8%	12.8%	23.1%	17.9%	15.4%	12.8%	100.0%
Chemical Manufacturing Industry	16	37	49	18	18	12	8	158
	10.1%	23.4%	31.0%	11.4%	11.4%	7.6%	5.1%	100.0%
Ceramics-Based Manufacturing Industry	8	15	17	6	6	6	6	64
	12.5%	23.4%	26.6%	9.4%	9.4%	9.4%	9.4%	100.0%
Metal-Based Manufacturing Industry	16	22	36	7	6	6	9	102
	15.7%	21.6%	35.3%	6.9%	5.9%	5.9%	8.8%	100.0%
Machinery Manufacturing Industry	16	31	30	9	6	6	7	105
	15.2%	29.5%	28.6%	8.6%	5.7%	5.7%	6.7%	100.0%
Other Manufacturing Industries	2	2	3		1			8
	25.0%	25.0%	37.5%	0.0%	12.5%	0.0%	0.0%	100.0%
Electricity, Gas, and City Water Industries	3	1	1	1	3	2	5	16
	18.8%	6.3%	6.3%	6.3%	18.8%	12.5%	31.3%	100.0%
Wholesaling Industry	16	14	19	15	5	9	17	95
	16.8%	14.7%	20.0%	15.8%	5.3%	9.5%	17.9%	100.0%
Retailing Industry		2	2		2	4	10	20
	0.0%	10.0%	10.0%	0.0%	10.0%	20.0%	50.0%	100.0%
Other Industries	1	1	3	2	2	5	4	18
	5.6%	5.6%	16.7%	11.1%	11.1%	27.8%	22.2%	100.0%
Total	98	152	203	89	86	78	88	794
	12.3%	19.1%	25.6%	11.2%	10.8%	9.8%	11.1%	100.0%

As above, as to the CO_2 emission in the term from 2006 to 2008, the percentage of the companies which significantly reduced their emissions was high in the production-goods-based manufacturing industry. The decrease of the amount of the freight due to the economic slowdown is also a factor for the above while it can be considered that the advancement of the various measures for reducing the CO_2 emission also significantly contributed to the above. At the same time, reduction of the costs was demanded in the production-goods-based manufacturing industry and, therefore, the advancement of the improvement of the physical distribution efficiency also influenced. The measures for reducing the CO_2 emission made progress in the manufacturing industry sector while the industries that act closely to the consumers using their supply chains such as the retailing industry and the wholesaling industry and, in addition, the electricity, gas, and city water industries each included many companies whose CO_2 emissions increased and these industries were behind the other industries in making efforts for the reduction.

7. CONCLUSION

Each of the specified freight carriers and the specified shippers is required to make efforts to reduce its energy consumption basic unit by 1% or more in average per year from a long- and middle-term viewpoint. The study has empirically analyzed how the CO_2 emissions varied, based on the data under the revised version of the "Law Concerning the Rational Use of Energy". As a result, the status has been confirmed where the total CO_2 emission relating to the logistics sector was reduced and, as to the CO_2 emission by company, many companies reduced their CO_2 emissions. The downward trend of the CO_2 emissions was especially remarkable in each of the business-use cars as to the specified freight carriers and the industrial-goods manufacturing industry as to the specified shippers. As above, it is determined that the enforcement of the revised version of the "Law Concerning the Rational Use of Energy" has achieved a degree of effect at present.

The analysis of the relation between the decrease of the CO_2 emission and its factors remains as a task to be considered from now on. It can be considered that the decrease is caused by the influence of the economic recession and, at the same time, the progress of the measures taken by companies. For the freight carriers, the most advanced efforts to achieve the reduction target included "introduction of low-fuel-consumption cars" and "eco-driving" and, for the specified shippers, "improvement of the load rate", "the modal shift", and "upsizing of vehicles" and, in addition, "redisposition, reduction, and consolidation of physical distribution bases", "introduction of low-fuel-consumption cars", and "utilization of returning vehicles (such as their use for procurement, and cooperation with vehicles for returning goods and out-of-service vehicles).

REFERENCES:

Yuji Yano ,Etsuo Masuda ,GyeongHwa Hong ,Hiroyuki Akiyama(2010),"Life Cycle Assessment of the Environmental Impact of Logistics", ISL2010.

Japan Environmental Management Association for Industry(2005),"2005 Guidelines for Implementing the Eco-leaf Environmental Label".

Huang Y. Anny ,Matthews H. Scott(2008),"Seeking opportunities to reduce life cycle impacts of consumer goods-An economy-wide assessment", 2008 IEEE International Symposium on Electronics and the Environment,p.1-6.

Joyce Smith Cooper , Liila Woods, Seung Jin Lee(2008),"Distance and backhaul in commodity transport modeling",The International Journal of Life Cycle Assessment Volume 13,Number 5.

Kato Hirokazu .Hayashi Yoshitsugu ,Goto Yuka(2002),"LCA Method on Environmental Impacts of Purchasing Action through Distribution Process", Proceedings of Annual Meeting of Environmental Systems Research,VOL.30th.

Anne-Mette M.Jørgensen,Peter E.Ywema,Niels Frees,Stephan Exner,Rolf Bracke (1996),"A comparative evaluation of the importance of transport in four LCAs", The International Journal of Life Cycle Assessment,Volume1, Number 4.

GREEN LOGISTICS ASSESSMENT: A METHODOLOGY TO MEASURE, EVALUATE AND IMPROVE THE ECOLOGICAL SUSTAINABILITY IN LOGISTICS

Prof. Dr.-Ing. Frank Straube, Dr. Stefan Doch
Berlin Institute of Technology / International Transfer Center for Logistics GmbH, Berlin

ABSTRACT
In the recent years environmental protection is getting to the top of the agenda in politics, society and customer behaviour. In literature the basic principles of sustainability are known for a long time. Nevertheless, actual research does not cover adequately the practical facets of ecological sustainability in logistics. Our objective is to present an integrated view on ecological footprint analysis and decision-making. Starting with an exploratory empirical survey study the actual objectives, challenges and developments of ecological sustainability in logistics were identified. Based on a brief literature review a blueprint of the methodology was developed. In an action research approach this concept was prototypical used for the calculation of current emissions of major logistics process configurations and the development of improvement possibilities out of the calculation results.

1 INTRODUCTION

Due to climate change, increasing environmental degradation and the depletion of natural resources, the public is developing an increased awareness for the importance of environmental and resource protection. Thus the Stern Review, published by Nicholas Stern in 2006, on the Economics of Climate Change transparently shows the economic consequences of climate change (Stern 2007). It is also clear that possible climate change would cost trillions and early prevention is more economically viable. Companies are, therefore, required to design sustainable products and services, as economic demands on account of various stakeholder groups and development are constantly gaining in importance. The same applies to the processes of value creation of a company which have to support environmentally sustainable procurement, production, distribution, use and recycling of products (Singh 2004).

The main influencing factors for the topic of "environment and resource protection" are the stakeholders within the economic environment of a company and especially the cost increasing factors, such as rising energy and commodity prices, partly resulting from the global shortage of raw materials. Recent studies show that in transport and logistics 30 percent of the total annual energy expenses of 180 billion euro are incurred in Germany (EyeforTransport 2007). Since logistics processes and transport are particularly identified with somewhat high fuel consumption, an exceptional challenge for logistics can be found here.

On the political level, this fact has been taken into account in the form of the appropriate climate change objectives, which have a direct or indirect impact on companies. The starting point for European policy on climate protection is the Kyoto Protocol, which prescribes the EU to reduce the six main greenhouse gases by 8% in the period from 2008 to 2012 in comparison to the levels of 1990. Although a continuation of international climate protection programmes after the failure of the conference in Copenhagen is uncertain, the EU continues to hold fast to its reduction targets (EU 2007). Based on a council decision, The EU has set the following binding targets for itself in March of 2007: reduction of greenhouse gas emissions by 20% compared to 1990, increasing the share of renewables for end user energy consumption to 20% and reducing primary energy consumption by 20% in regard to a projected business-as-usual scenario.

It is, therefore, necessary to meet these requirements of the stakeholders and analyse the complete life cycle of products and their entire value creation chain with regard to environmentally sustainable aspects as well as to organise them according to the wishes of the customer (Beamon 1999). Currently, it should be noted, however, that environmentally sustainable logistics services are usually limited to the measurement of CO_2-emissions and these services only occur sporadically. Accordingly, customers have not become aware of these service offers yet on a broad level and have also not demanded them. Therefore, environmental aspects currently only play a role for one third of customers for purchasing common consumer goods such as textiles or toys. However, the protection of resources has increasingly developed into a major selling point for end customers and employees as they are being sensitised to these topics through the media.

It is, therefore, the objective of this paper to enable companies to a more sustainability oriented action taking. It will be shown that it is necessary to analyse logistics processes regarding their actual emission level and to systematically identify optimization possibilities. This process of measurement and improvement has to be supported by appropriate decision support methods and systems. The main purpose in this context is to identify the factors that influence a successful implementation of ecological sustainability concepts.

This implementation affects almost all business sectors and particularly logistics. An essential requirement for logistics for example is to reduce greenhouse gas emissions. Based on estimates, up to 75% of the so-called carbon footprint, for example harmful CO_2-emissions of companies, can be attributed to the transport and logistics industry and clearly demonstrates the current need for action to increase the environmental sustainability of the logistics industry. With regard to the total CO_2-emissions which, in the context of the Stern report, are broken down into the sectors of energy (24%), industry (14%), transportation (14%), buildings (8%), land use (18%), agriculture (14%), waste (3%) and miscellaneous (5%), the great responsibility of the logistics industry becomes apparent (Stern 2007). Logistics processes are not just responsible for a relevant share of transport-related emissions, but also for a part of the emissions caused by industry, buildings and waste.

Knowing about this macroeconomic share of transport-related emissions, companies are looking for hints on their individual share on total emissions. An accurate calculation of the actual emission level for individual companies and single logistics processes can lead to transparency for logistics management on that issue. Therefore ecological measurement methods and tools are on the actual agenda of most companies. While companies are able to report their current emission balance by that, little support is given for the identification of optimization potentials. Therefore, the design of a methodology that goes beyond reporting purposes is the ultimate goal of this paper. The research approach is oriented on a qualitative and applied research process: Based on a brief literature review (section 2) a blueprint of the methodology will be developed (section 3). In an action research approach this concept will be prototypical used for the calculation of current emissions of major logistics process configurations and the development of improvement possibilities out of the calculation results in a multinational industrial company (section 4). The insights out of that practical concept application will be aggregated in a generalised methodology to measure, evaluate and improve the ecological sustainability in logistics.

2 ECOLOGICAL SUSTAINABILITY IN LOGISTICS

One of the most well-known definitions of sustainability is the one of the World Commission on Environment and Development (WCED) initiated by the UN General Assembly in 1983 (United Nations 1983). According to the commission’s final report, a development is to be recognised as sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations 1983).

The definition, in line with the principle of distributive justice and widely used in the past, does convey some idea about the concept of sustainability, but it is too broad and unspecific for use in a micro-economic context. It is for this reason that organisations have often found it difficult to find their individual role in this overall macro-economic context.

The triple bottom line developed by Elkington provides a more detailed overview over possible characteristics of the sustainability of companies (micro-economic context). This model requires companies to implement their value creation in such a manner that capital preservation is not compromised. In regard to capital, there is a distinction between economic, natural and social capital. Accordingly, this model divides the sustainability of companies into three dimensions: social, environmental and economical sustainability (Elkington 1998).

In literature the basic principles of sustainability like the triple bottom line, the relation of sustainability and competitive advantage or the role of ethics and regulations in sustainability are known for a long time (Srivastava 2007). In logistics a wide range of sustainability topics such as design for green logistics, remanufacturing and reverse logistics, green logistics network design, sustainable procurement, sustainability KPI's or green routing and location optimization are discussed (Zhu et al. 2008). In addition, latest publications focus on interorganizational and collaborational aspects of sustainability (Vachon & Klassen 2006). In literature three different theoretical concepts do influence the discussion on environmental sustainability in logistics. General supply chain theory includes important aspects such as collaboration, process orientation and total costs but is not yet aware of the performance dimension of environmental sustainability. On the other hand environmental concepts like material flow management (Wagner & Enzler 2005) and environmental management do have that focus on the environmental perspective. Environmental sustainability can, therefore, also be understood to be the implementation of environmental and resource protection. The company management must make decisions not only based on economic considerations but also on the basis of social and environmental requirements, so a balance may ensue while meeting these requirements. While the logistics of companies since their development was geared toward efficiency and increasing economic performance and, due to social requirements, for a long time especially toward employees, the third dimension has gained considerably in importance in the recent past. Environmental sustainability as a target dimension for logistics as well as the discussion about a so-called Green Supply Chain Management has evolved since the early 90s as part of recycling management and reverse logistics for example. In the recent past, this topical area has once again gained in importance. Green supply chain management is often understood in literature as the sum of environmental management and traditional supply chain management concepts. Green supply chain management serves to reduce risks and implement process innovations. Green supply chain management also includes aspects for the design of supply and customer relationships, which result in an expansion of approaches to sustainability in the supply chain. Darnall, Jolly and Handfield researched and empirically evaluated the relationship between environmental management systems and green supply chain management. The results showed that companies using environmental management systems tend to more readily implement green supply chain management systems than those that do not use environmental management systems (Darnall et al. 2008). It was stressed here that environmental management systems in supply chain management do not affect environmental sustainability within a company but cover the entire supply chain of the company. In his discussion of current literature on green supply chain management, Srivastava (2007) comes to the conclusion that this has not yet been sufficiently established in the companies. Also, it is noted that a concise systematisation of the subject area is required to promote an increasing recognition and integration of green supply chain management systems. Other authors point to the increasingly observable degree of effort to establish green supply chain management approaches (Hoffren & Apajalahti 2009, Darnall et al. 2008, Halldorsson et al. 2009). The concept of green supply chain management is becoming an all-encompassing environmentally relevant initiative in the areas of procurement, logistics, production, distribution logistics and disposal logistics with the involvement of suppliers, service companies, distributors and end users. As key leverage for green supply chain management, cross-company co-operation with the overall goal of conserving resources is mentioned. This view is based on the fact that potentially more and more effective solutions to environmental challenges are developing through customer and supplier integration and are implementable, as it is the case when taking an isolated, business related viewpoint. It is assumed that cross-company partnerships or projects with customers result in higher quality and greater flexibility while those with suppliers primarily promise efficiency gains. A comparison between supply chain management, as a holistic optimisation and management concept, and the environmentally focused concepts of material flow and environmental management represent approaches to reciprocal integration (see figure 1).

The most significant commonality of the three management approaches is the focus on increasing the competitiveness of the company. Additionally, a consideration of resources and products takes place, and a process optimisation to improve performance is encouraged. Cooperation and communication for optimising interfaces are essential for implementation, whereby an environmentally oriented supply chain management emerges, which regards the logistical goods and information flows from an environmental viewpoint. To achieve economic and environmental objectives, a holistic view of the cost, service and environmental performance the total supply chain is needed. Environmentally sustainable logistics must act as a bridge between the resource-intensive processes in the company and the environmental demands of stakeholders (McIntyre et al. 1998). Therefore, there is already a demand during the design of a product for example and, thereby, during the designation of volume and weight, to achieve an agreement and a coordination with logistics in order to guarantee an optimal procurement and distribution (Design for Logistics) (Aronsson et al. 2006).

In total, earlier works have a limited focus and narrow perspective (Zhu et al. 2008, Darnall et al. 2008, Halldorsson et al. 2009, Aronsson et al. 2006). They do not cover adequately the practical facets of ecological sustainability in logistics and do not have the goal to present an integrated methodology to measure, evaluate and improve the ecological sustainability in logistics. Our objective is to present an integrated view on ecological footprint analysis and decision-making. This leads to the following research question: What elements and process steps should a methodology consist of, that supports the measurement, evaluation and improvement of the ecological sustainability in logistics?

3 REVIEW OF CURRENT MEASUREMENT METHODOLOGIES OF ECOLOGICAL SUSTAINABILITY IN LOGISTICS

Many measurement models for evaluating emissions in the field of logistics share a common focus on the processes of transport logistics. Often they have their origin in scientific institutions or organisations and have been designed for non-commercial purposes. A short synoptic view of their principle characteristic will be presented below.

GEMIS 4.5 - The Global Emissions Model of Integrated Systems is a computer programme for the comparative study of the environmental effects of energy provision and utilisation (Fritsche & Schmidt 2008).

TREMOVE 2.7b - TREMOVE is a transport and emission simulation model which has been developed by the Catholic University of Leuven and by Transport & Mobility Leuven for the benefit of the European Commission (De Ceuster et al. 2007).

COPERT 4 - COPERT 4 is a software programme which evaluates air pollution emissions caused by street traffic. The technological development of COPERT is financed by the European Environment Agency (EEA), a programme within the framework of the activities of the European Topic Center on Air and Climate Change (Gkatzoflias et al. 2007).
HBEFA 2.1 - The environmental agencies in Germany (UBA), Austria (UBA) and Switzerland (BUWAL) have for many years promoted various research projects and measurement sequences to evaluate the extent of air pollution caused by traffic and appropriate measures for pollution reduction (Pischinger 2002).
TREMOD 4 - The emission evaluation model TREMOD (Transport Emission Model) describes the motorised street, railway, ship and air traffic in Germany in matters pertaining to traffic and driving performance, energy consumption as well as the related air pollution emissions for the time period of 1960 to 2030 (IFEU 2005).

In summary, one may affirm that measurement models like GEMIS, TREMOVE, COPERT, HBEFA and TREMOD exhibit the following deficits:

- Depictions of cause and effect correlation between logistical influencing factors (for example use to full capacity, the stockpile factor of palettes) and measurement parameters are insufficient.
- There is no exhaustive consideration of all emission types and a lack of comparability or overall evaluation of all emission types.
- There is no illustration of sensitivities for environmental measurement parameters and, closely related to this point, no holistic system for substantiated derivation of tangible activity fields and measures.
- A link between environment, process and financial key figures to evaluate performance and cost for active measures and their environmental effects is also missing.
- Many measurement models are isolated and were not designed with integration into existing (logistics) controlling systems in mind.

Drawing a comparison of these deficits with the implementation issues of ecological sustainability in logistics shows the major requirements on an ecological measurement framework. A measurement methodology has to support cause and effect analyses and sustainability KPIs to overcome the operationalization gap shown in figure 2. Methodological flexibility and compatibility can be concluded as the major success factors for the implementation of ecological measurement systems for decision support.

4 DEVELOPMENT OF A METHODOLOGY TO MEASURE, EVALUATE AND IMPROVE THE ECOLOGICAL SUSTAINABILITY IN LOGISTICS

The point of origin for the development of a methodology for measurement, evaluation and enhancement of ecological sustainability for the field of logistics is formed by defining those environmental factors which need to be integrated. Environmental influences are understood to be the environmental strain caused by pollutant emitters. Another form of emission is noise emission. It mainly affects humans and not the environment as a whole. Significance must also be attributed to the environmental effects of surface area consumption through industry and traffic and to the effects of the fragmentation of natural landscapes. Ecological and ethical considerations reveal another form of influence, namely the use of limited, natural resources and energy sources. Pollutants are generally regarded as substance emissions (of natural and anthropogenic origin) which damage an organism or system. In this case these may be substances which previously have never or seldom been present in a system, but they may also be emissions which disturb the balance of a system through an increased influx of a pre-existing substance (Fonger 1993). The main focus of logistics is on the problems arising from air pollution of energy conversion through combustion engines, factories and production. The most important substances in this context are: the nitric oxides (NOx), carbon dioxide (CO_2), dust and soot particles, and ozone near the ground (as a photochemical product of other pollutants) as well as the fleeting organic compounds

(VOC), caused by incomplete combustion. The main sources of nitric oxides can be traced back to traffic (yet with a greatly diminished tendency since the introduction of catalytic converters), other mobile sources (including especially ship transportation), power generation and agriculture (fertilisers, animal farming). Besides the tropospheric water vapour, carbon dioxide (CO_2) is the most important climatically relevant trace gas. The natural, dynamic balance is increasingly being disturbed by the combustion of fossil fuels. These anthropogenic CO_2-emissions are above all made responsible for the climatic changes which are summarized as the greenhouse effect. The main sources of dust and soot particles are the energy harnessing industry and traffic (combustion processes). In recent years it has been possible to reduce particle emissions - yet it was only during this development that the severe threat of fine dust particles has been recognised. Until 1990 the main cause of VOCs was assumed to be traffic (incomplete combustion, but also the evaporation of fuels), but today, on account of the substantial reduction of traffic emissions, the most essential source categories are the use of solvents and fertilisers as well as the emissions from production processes and small combustion facilities. Noise is defined as a sonic sound of an intensity perceived to be disruptive. In this context the sentience of noise has a strong subjective variance and results in a basic problem of evaluation. Among the main noise sources are traffic and specifically freight traffic alongside the producing industries and construction. In the framework of surface area consumption, one may distinguish between primary landscape consumption as a sealing of areas and the complementary landscape consumption as a consumption and usage of adjacent areas or the fragmentation of landscapes. Generally speaking, the external costs of surface area consumption and the visual impairment of the overall appearance of the landscape are somewhat marginalised in comparison with the other external effects. Concerning the aspect of finite resource consumption, one must affirm that an economic evaluation of consumption proves to be difficult, since neither the existing quantity nor the prospective demand can be determined with certainty. Moreover, the technological innovations and substitution possibilities for the respective natural resource can hardly be predicted in the long-term.

The developed model for measuring and evaluating emissions of logistical processes serves to ascertain and compare environmentally relevant emissions, such as CO2, NOx, VOCs, fine dust particles, surface area consumption and noise. The model is applicable to any inbound and outbound process and permits assertions about the value of total emissions and also about the distribution of emission types in the process sequences of logistics.

The developed evaluation procedure is based on the fundamental assumption that basic logistical processes, such as transport and transhipment, are characterised by the physical movement of freight, requiring the intentional deployment of energy. The cause for the demand on energy and, thereby, the propeller of emissions is the expenditure to overcome various resistances of movement whose specific value imminently depends upon the driven route, the mass to be moved, the type of vehicle and the speed of movement within the framework of transport processes. The overall measurement process is shown in figure 3.

In order to reduce the evaluation expenditure, various simplifications of the evaluation procedure become necessary. Regarding the ascertainment of relevant influential factors, these simplifications can be realised in various ways:

- Simplification via the formation of factors for certain influential factors (for example co-efficients of roll and air resistance for average acceleration)
- Linear convergence via the formation of average values (for example route profile, age of vehicle fleet)
- Convergence via cluster and category formation (for example average speeds and acceleration proportions, clustered according to various street types and day time zones)

Within the framework of the evaluation and the designation of various emissions, average and/or threshold value related conversions of energy consumption or consumptions for utilised energy carriers are used. It must be noted that the evaluation takes direct and indirect emissions into consideration, but not emissions from previous chains (for example the infrastructure for power generation).

In general environmental improvements can be seen on the level of the product, the structure of the logistics systems, the planning and management of the logistics processes and on the operational and technological level (Straube & Pfohl 2008). An appropriate evaluation technique has to be chosen for each of these areas of environmental improvement. For showing the influence of single operational improvements like better transport routing or the use of environmentally friendly technologies the analysis of the sensitivity of relevant input factors can be a useful technique. Knowing that for example the transport distance has an influence above average on the emission level, relevant improvements can be prioritized. For the selection of appropriate planning and management approaches more complex evaluation methods are needed. Redesigning the production or transport planning systems can influence the ecological sustainability in different ways. By that the evaluation of different planning approaches has to be done by the comparison of different process configurations. The same evaluation technique has to be taken into consideration for the evaluation of different supply chain structures. On an even higher design level like the overall strategy or the product design even more possible trade-offs have to be taken into account. For most operational and management improvement an influence on the different emissions in the same direction can be observed. When comparing different transport modes, supply chain structures or product configurations the effects on the different emissions can be oppositional. In order to weight the various types of emissions according to their environmental effect and, thereby, achieve comparability, the method of ecological scarcity is implemented. The term ecological scarcity was coined in 1974 on the basis of ecologically sustainable substance fluency (BUWAL 2009). The objective is not only to record industrial effects on the environment, but also to enable these effects to be managed using environmental policies. The basic principle behind this is the concept that the environment is able to endure a certain amount of strain (emissions, resource depletion etc.); this strain must be distributed across the various sources of pollution. By use of ecological factors the various environmental effects are converted into environmental damage points, which permit a comparability of environmental strains for various emissions on the one hand and varying logistics processes or configurations on the other. The evaluation of ecological factors takes the current environmental situation into account, the present standardised environmental situation as it pertains to the referential size and the target situation, pursued by environmental policies (governmental environmental policy priorities). The fit of the different evaluation techniques and the targeted areas of improvement are shown in figure 4.

The presented Green Logistics Assessment methodology was successfully used in different ecological sustainability projects. One practical case study of the Green Logistics Assessment application will be described. The starting point of the case study company, a large multinational industrial goods producer, was the objective to gain insights into the management of ecological aspects in logistics by starting optimization projects on single logistics processes. One of the selected processes was the distribution process of finished industrial goods from European factories to the port of Hamburg. From there, the goods were shipped to an industrial building site in China. The total sales volume of the selected project was 50.000.000 €, consisting of 250 tonnes of goods. At the beginning the logistics process was analysed in detail. The process included a packaging process near the factory, the road transport to a warehouse in the port area, the containerization of the goods, the transport of the packed containers to the port terminal and the loading on board of the container vessel. For each process step the used logistics equipment, the quantity structure and detailed material flow was analysed in detail by structured interviews. Based on these input information the calculation of the emissions for the

actual process configuration was done. The calculation results show a total energy consumption of 65.000 kWh differentiated in minor 50 kWh energy for the packaging and transhipment process, 62.350 kWh for the transport process, 150 kWh for the containerization and warehousing process, 950 kWh for the transport from the warehouse to the port terminal and 1500 kWh for the loading on board. Using the presented emission factors the different emissions and the total emission was calculated. In the evaluation phase of the project the presented evaluation technique of sensitivity analysis was applied to develop a cause-and-effect relationship model for possible environmental improvements. A summary of this analysis is shown in figure 5.
The different improvement potentials were discussed at a management workshop, including representatives of the shipper, the logistics service providers and the terminal and port company. The realization opportunity for each option were analysed and financially evaluated. The major ecological improvements the management workshop agreed on are a modal shift to rail transport, the early containerization of the goods at the beginning of the distribution process, and the postponement of the shipping to the latest date to avoid the warehousing process near the port. For this alternative configuration a new Green Logistics Assessment calculation was proceeded. The environmental improvement in terms of CO2-emissions as well as a comparison of logistics costs and transport lead times are presented in figure 6.

5 SUMMARY

In total, the described case study shows the usefulness of an integrated methodology for the measurement, evaluation and improvement of the ecological sustainability in logistics. The presented Green Logistics Assessment methodology is oriented on a process companies are choosing for their green logistics projects. The methodology supports companies on each single step in decision-making and does not end up with a calculation result of the actual process configuration. By including all relevant emissions in the methodology, one single approach is appropriate for most company requirements. The approach offers methodological flexibility by using a physical and open-source calculation logic as well as open calculation factors and data. The methodology can be individually customized on company specific data availability and objectives as well as on changing regulatory standards. Decision support is realized by orientating the design of the calculation method on the logistics planning and management logic and not on macroeconomic reporting practices. While logistics planning is demanding for detailed insights into the cause-and-effect relations of logistics practices and ecological emissions, reporting purposes have to deal with a much higher level of aggregation. The research on the interoperability of ecological reporting and ecological planning support systems should therefore be on the agenda of further research. In the area of decision support Green Logistics Assessments enables companies to build up ecological KPIs. While single optimization decisions can be argued with these KPIs, complex network related issues need holistic systems of metrics rather than single KPIs. In the next steps of the research the focus should be on the evaluation of the influence of emissions on logistics costs and service quality. A long-time objective can be seen in having objective sustainability KPIs in logistics that allow a comparison of ecological performance to cost and service levels. By that process and structure alternatives can be evaluated and logistics management can force top management decisions on what investments are needed to reach a certain ecological performance level. The case study has shown that ecological sustainability is one planning dimension of the logistics process. Having an integrated decision-making process that not only includes emissions but also logistics costs and service levels will be even more beneficial for companies and can boost the implementation of sustainable solutions in logistics. The key success factor for that is the integration of evaluation and decision support methods into the measurement methodology itself. Research should focus on this issue by evaluating the capabilities of measurement methodologies and processes under the logistics planning rather than the reporting point of view.

6 REFERENCES

Aronsson, H.; Brodin, M. H. (2006): The environmental impact of changing logistics structures, The international Journal of Logistics Management, Vol. 17, No. 3, p. 394-415.

Beamon, B. M. (1999): Designing the green supply chain, Logistics Information Management, Vol 12, No. 4, p. 332-342.

Brown, D. (2008): Environmentally friendly credentials are influencing business outsourcing decisions, Strategic Outsourcing: An International Journal, Vol. 1, No. 1, p. 87-95.

BUWAL (2009): Die Methode der ökologischen Knappheit, http://www.bafu.admin.ch/publikationen/publikation/01031/index.html?lang=de&download=NHzLpZig7t,lnp6I0NTU042l2Z6ln1acy4Zn4Z2qZpnO2Yuq2Z6gpJCGdoF9fWym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2IdvoaCVZ,s-.pdf.

Ceuster, G.; Herbruggen, B.; Ivanova, O.; Carlier, K.; Martino, A.; Fiorello, D. (2007): Service contract for the further development and applica- tion of the transport and environmental TREMOVE model Lot 1 (Improvement of the data set and model structure), http://www.tremove.org/documentation/Final_Report_TREMOVE_9July2007c.pdf.

Darnall N.; Jolly J.; Handfield R. (2008): Environmental Management Systems and Green Supply Chain Management: Complements for Sustainability?, Business Strategy and the Environment 2008, Vol. 17, No. 1, p. 30-45.

Endres, A.; Bertram, R.; Finus, M.; Rundshagen, B. (2007): Umweltökonomie; Verlag Kohlhammer; Stuttgart 2007.

Elkington, J. (1998): Cannibals with Forks: The Triple Bottom Line of the 21st Century. Stoney Creek.

EyeforTransport (2007): Green Transportation & Logistics, Summary and analysis of eyefortransport's survey, London, 2007.

Fritsche, U.; Schmidt, K. (2008): Global Emission Model of Integrated Systems (GEMIS): Öko Institut, Darmstadt, http://www.oeko.de/service/gemis/files/doku/g45_manual.pdf.

Fonger, M. (1993): Gesamtwirtschaftlicher Effizienzvergleich alternativer Transportketten (multimodaler Verkehr). Göttingen: Vandenhoeck & Ruprecht.

Gkatzoflias, D. ; Kouridis, C. ; Ntziachristos, L. ; Samaras, Z. (2007): COPERT 4 : Computer programme to calculate émissions from road transport, http://lat.eng.auth.gr/copert/files/tech01.pdf.

Halldórsson, A.; Kotzab, H.; Skjøtt-Larsen, T. (2009): Supply chain management on the crossroad to sustainability: a blessing or a curse?, Logistics Research, Vol. 1, No. 2, p. 83–94.

Hoffren, J.; Apajalahti, E.-L. (2009): Emergent Eco-Efficiency Paradigm in Corporate Environment Management, Sustainable Development, Vol. 17, Nr. 1, S. 233-243.

IFEU (2005): Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030, http://ifeu.de/verkehrundumwelt/pdf/IFEU(2005)_TREMOD_Grundlagenbericht_Zusammenfassung.pdf.

McIntyre, K.; Smith, H.; Henham, A.; Pretlove, J. (1998): Environmental performance indicators for integrated supply chains: the case of Xerox Ltd. Supply Chain Management, Vol. 3, No. 3, p. 149-156.

Pischinger, R. (2002): Update of the Emission Functions for Heavy Duty Vehicles in the Handbook Emission Factors for Road Traffic, http://www.hbefa.net/e/documents/DACH_SNF_Endbericht.zip.

Seuring, S.; Müller, M. (2008): From a literature review to a conceptual framework for sustainable supply chain management. Sustainability and Supply Chain Management. Journal of Cleaner Production, Vol. 16, No. 15, p. 1699–1710.

Singh, M. (2004): A Review of the Leading Opinions on the Future of Supply Chains; Supply Chain 2020 Project Working Paper. MIT, Boston, Massachusetts.

Srivastava, S. K. (2007): Green supply-chain management: A state-of-the-art literature review. In: International Journal of Management Reviews, Vol. 9, No. 1, p. 53–80.
Stern, N. (2007): The Economics of Climate Change - The Stern Review; Cambridge University Press; Cambridge.
United Nations (1983): Process of preparation of the Environmental Perspective to the Year 2000 and Beyond. General Assembly Resolution 38/161. New York.
Vachon S.; Klassen R. D. (2006): Extending green practices across the supply chain: The impact of upstream and downstream integration. International Journal of Operations and Production Management, Vol. 26, No. 7, p. 795-821.
Wagner, B.; Enzler, S. (2005): Material Flow Management: Improving Cost Efficiency and Environmental Performance. Physica,.Heidelberg. 2005.
Zhu Q.; Sarkis J.; Lai K. (2008): Green supply chain management implications for "closing the loop". Transportation Research Part E, Vol. 44, No. 1, p. 1-18.

Figure 1: Supply Chain Management, material flow management and environmental management

	Supply Chain Management	**Material Flow Management**	**Environmental Management**
Objective	Efficiency and effectiveness of the Supply Chain in terms of costs, quality and service	Reduction of environmental impact by lowering anthropogenic material flows and the substitution of materials	Implementation and continuous improvement of the environmental management system (for example ISO 14001) and improvement of the corporate environmental performance (for example EMAS)
Strategic base	Fundamental logistics principles like total cost orientation, process integration, etc.	Environmental management principles	Environmental management principles
Object	Material, information and financial flows	Those Physical material and energy flows that have an environmental impact	Environmental governance, strategy, objectives, management systems and reports
Actors	Focal company, suppliers and customers	One or more companies and their stakeholders	One company or company's site and the stakeholders
Cooperation	Horizontal and vertical	Horizontal and vertical	Not specified
Methods	Process analysis, optimization methods, etc.	Material flow reports and calculation	Environmental audits and reports

Figure 2: Summary of the review of current measurement methodologies

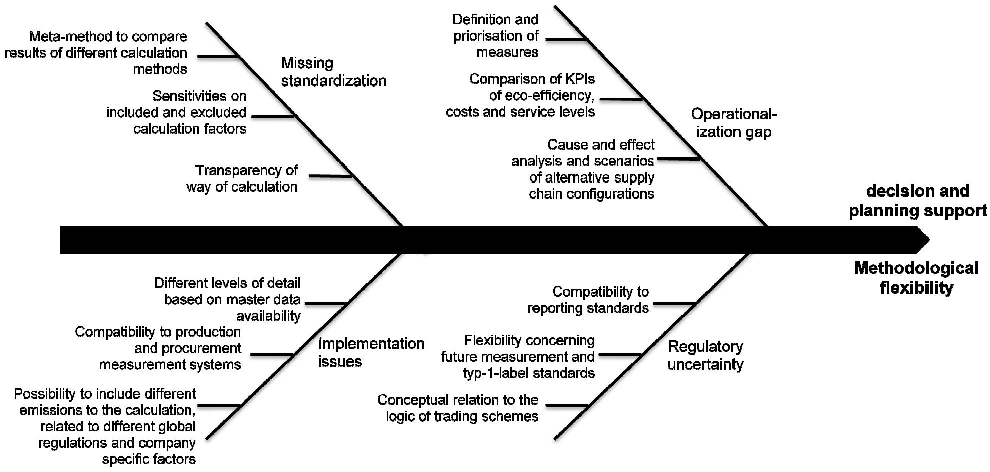


Figure 3: Measurement process of Green Logistics Assessment

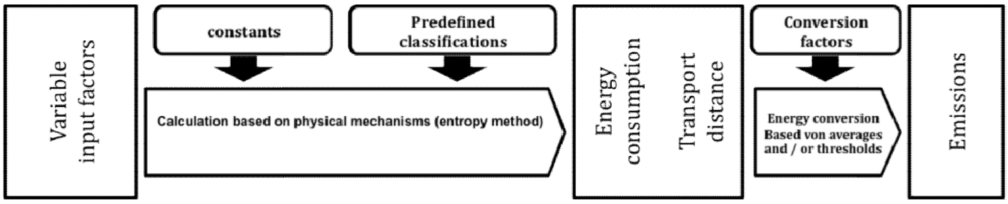


Figure 4: Fit of used evaluation techniques and targeted area of improvement

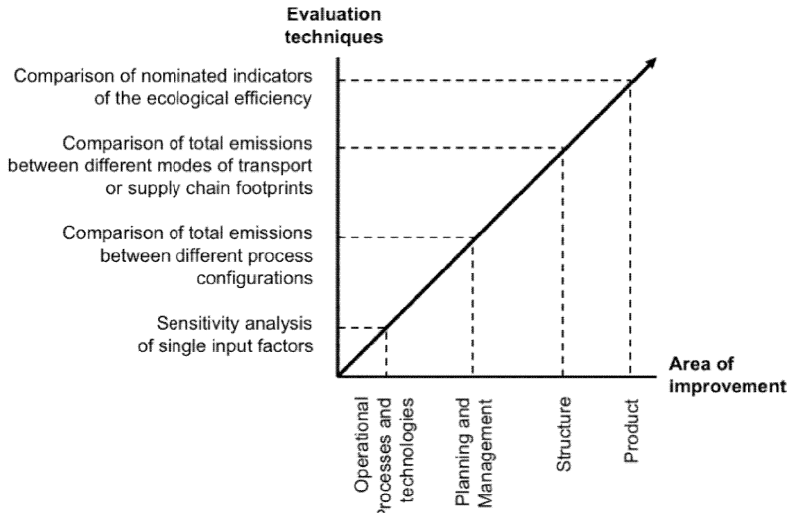
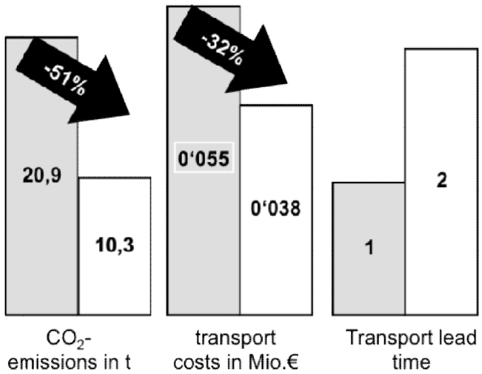


Figure 5: Cause-and-effect analysis in the different improvement dimensions

Improvement dimension	**Cause**	**Effect**
Technology	- Age of trucks - Alternative actuation - Alternative fuel - Electrification	- Energy efficiency - Resistances - Emission factors
Driver's behavior	- Economic driving	- Lower speed - Less acceleration
Mode of transport	- Alternative modes of transport	- Emission factors - Trade-offs between degree of utilization,

		transport distance, transport emissions
Supply chain structure	- Fewer process steps - Decupling point	- Fewer handling and warehousing processes
Transport management	- Delivery frequency - Degree of utilization - Distances	- Number of transports - Volume and Weight - Distances
Loading equipment	- Packaging	- Weight - Fewer repackaging processes

Figure 6: Comparison of emissions, logistics costs and transport lead time



eFREIGHT ADOPTION FOR SUSTAINABLE AIR TRANSPORT SUPPLY CHAIN

M. Goh[1], A. Tan, M. Garg, H. Othman, R. de Souza
The Logistics Institute-Asia Pacific, NUS
[1] and School of Management, University of South Australia

ABSTRACT
With a growing increasing awareness of global warming and the consequences of economic activities on the environment, governments, industries, and enterprises are re-examining their business practices in search of eco-friendly alternatives. This paper presents a process re-engineering approach to harnessing technology and digital information to reduce greenhouse gas emissions in the air freight supply chain, using the international export documentation process of the air freight sector in Singapore as a case study. The export documentation processes of four business verticals dominant in air freight are compared through focus group discussions, site visits, and interviews. The intent is to quantify the cost savings and potential value creation of e-freight adoption for various stakeholders in the supply chain.

Keywords: Process re-engineering, e-freight, case study, Singapore

INTRODUCTION

Businesses are increasingly confronted with the implications of global warming and climate change (Oglethorpe and Heron, 2011). According to Srivastava [12], organisations that actively partake in combatting global warming do not just help the environment but also have much to gain through one or more of the following ways: (i) Increasing the efficiency of the supply chain leading to a reduction in operating costs, (ii) Better understanding the potential carbon related taxes, tariffs and other "green" legislations, and (iii) Improved market reputation and corporate image giving rise to the newly minted and well regarded green brand. In this regard, it has also been recognized that one of the main culprits in greenhouse gas emissions in transport and logistics is in air transportation, an increasingly important pillar in the global supply chain. Indeed, the rapid growth of air transport both domestically and internationally in recent years particularly has led to a EU report stating that in the EU, greenhouse gas emissions from aviation increased by 87% between 1990 and 2006.[3] The International Air Transport Association reports that global air freight in 2010 alone grew by 5-6% on an annualized basis, which does not help matters (IATA, 2010). As such, there is now a recognition and renewed effort by the governments, regulators and other stakeholders to encourage better efficiency of aircraft and their operations, through better use of information technology, promoting green information technology and green information systems.

E-freight, an IATA initiative which started in 2004, aims to reduce the amount of paper documents in the air freight supply chain by moving to a paper-free, electronic environment. The program aims to enhance efficiency and competition in the industry by effecting a shift to a fully electronic supply chain system, and eliminating the use of paper documents in freight business conduct. IATA has estimated that automating and standardising business systems through IATA's e-freight format can yield savings of up to $4.9 billion in cost throughout the international supply chain. This saving is equivalent to 64 percent of the paper consumed in the business transactions of this business.

Presently, an average air freight shipment can generate up to 30 different paper documents, including the 20 essential documents such as the airway bills (IATA, n.d.). Indeed, by replacing paper documents with electronic messages, the supply chain actors can benefit from cost reduction, reduced paper trail, shortened processing time, increased data accuracy, and reduce any overlapping functions (Hertz, 2006). E-freight

[3] http://en.wikipedia.org/wiki/Environmental_impact_of_aviation#cite_note-3.

involves all players in the air cargo community namely the airlines, shippers, freight forwarders, ground handling agents, the airport authorities, and customs. IATA in 2010 has further appealed to members involved in the air freight cargo value chain to support this IATA e-freight initiative as it is sustainable and environmentally friendly.

According to the Boeing World Air Cargo Forecast 2008-2009, the world air cargo market is expected to grow by 5.8% in the next two decades, tripling from 193.6 billion RTKs in 2007 to more than 595.9 billion RTKs in 2027.[4] Asia, especially intra-Asia trade and domestic China is expected to have the highest growth.[5] This in turn is encouraging airlines to ramp up capacity by investing in larger freighters (Boeing's 747-8 freighters) to accommodate the growing cargo volumes and shipments. However, in the conduct of this business, where cargo security is a growing business item, more freight documentation and work is expected. In addition to augmenting the physical infrastructure, the air cargo community has also increased effort to improve the efficiency of the flow of information in the air cargo process, improving the necessary speed to market especially at the land- and terminal- side of the business.

Since its launch, IATA has closely monitored e-freight adoption across the world. According to IATA figures, monthly e-freight consignment growth by volume was 4%, recording an increase of 1,757 consignments in July 2010.[6] The total e-freight by number of freight consignments was 47,501 worldwide (including domestic and international e-freight consignments) in 2010. South Korea is ranked as the top e-freight destination location (by volume for domestic and international e-freight consignments), followed by the US, Spain, Singapore and Germany. Each air cargo shipment carries with it as many as 30 paper documents, which is enough to fill 80 Boeing 747 freighters each year.[7]

In this paper, we apply process re-engineering on the international air freight documentation flow through Changi Airport in Singapore. There is good reason for doing so. First, Changi Airport is the seventh busiest cargo airport globally in terms of international air freight, handling about 1,813,809 tonnes of cargo in 2010 (http://www.changiairportgroup.com/cag/html/the-group/airfreight_movement.html). In freight documentation terms, this amounts to at least 4 million page documents annually. Reducing paper documentation will therefore improve the overall efficiency and reduce wasteful paper consumption, significantly shrinking the carbon footprint of the air freight industry. Second, due to Singapore's large electronics sector, electrical components constitute a significant part of the traditional total cargo traffic handled at the airport. Given the short half life of the electronic sector, there is a compelling commercial need to shorten the processing time for this class of air cargo so that the electronic parts or components can reach the next stage of the production value network as quickly as possible. Hence, electronic documentation is useful in this instance. Third, given Singapore's attempts to diversify into the perishable air cargo market in time sensitive areas such as life sciences, clinical testing, ornamental fish, moving freight documentation to an electronic platform is again an imperative. This case study therefore examines the redesign of the existing e-freight process in Singapore, and presents a value analysis (through a cost benefit analysis) for a greener supply chain. Through this work, we hope that the paper can serve to show how technology can be harnessed to enhance security, sustainability, and savings in time and cost.

RESEARCH METHOD

Given the exploratory nature of the study and the difficulty in estimating the cost saving and value creation, it was felt appropriate to solicit views from the user community and rely on qualitative means to provide grounded theory to the practice. Further to achieve

---

4 http://www.boeing.com/commercial/cmo/index.html
5 ibid
6 http://www.iata.org/whatwedo/cargo/efreight/Documents/r17-ef-monthly-volumes.pdf
7 http://www.iata.org/whatwedo/cargo/efreight/Pages/index.aspx

a deep understanding in this research effort (Woodside, 2010), we employed the following triangulation means: (i) direct observation within the environments of the case by undertaking a number of site visits to the freight forwarders' workplace, (ii) we probed by asking the stakeholders through focus group discussions, and (iii) we scanned the open domain archival data and analysed the written documents especially those related to the IATA initiative on digital documentation.

In the first part of the study, site visits were organized to both the SME freight forwarders such as Astro Express and Freightment, and MNC freight forwarders such as DHL Global forwarding, and IT vendors such as Crimson Logic, so as to visually see the air export process freight documentation and physically observe in real time the actual activities engaged in documentation. During the site visits, the issues in documentation raised by or asking of the participants during spontaneous conversation were also recorded and used as input for the second stage of the research method triangulation. This serves to provide a deeper understanding of the nuances of the e-freight process (Arnould and Wallendorf, 1994).

In the second part of the case study triangulation, six in-depth focus group discussions with the industry stakeholders were organized in a closed door, open sharing environment over a span of three months. Focus groups are carefully planned discussion sessions designed to obtain perceptions in a defined area of interest within a permissive, non-threatening environment (Kruger, 1988). To determine the composition of the focus groups, the key commodities transported by air in Singapore were identified through the spontaneous conversations held with some of the hosts of the site visits and from the open domain literature especially those from Civil Aviation Authority of Singapore. Four industry verticals - Automotive and Aerospace (Volkswagen, Air France-KLM Cargo, SIA Cargo), Electronics (Fairchild Semiconductor, Future Electronics, ST MicroElectronics, Infineon), Chemicals and Pharmaceuticals, and Perishable Goods (Union Air Freight, Freightmen) were identified as significant users / stakeholders in air freight. Two additional focus groups consisting of the Small and Medium (SME) sized freight forwarders (Altus Logistics) and IT Vendors (Crimson Logic) were also conducted to provide completeness to our understanding of the shift to a digital platform in air freight documentation.

A questionnaire was prepared to guide the focus group discussions of 1.5 hours each. The As-Is process for the air cargo export process and the associated documentation was mapped and introduced during the discussions. The case participants were also introduced to the concept of e-freight@Singapore in each discussion. In each focus group discussion, precaution was also taken to ensure the active participation of representatives from the SMEs as well as the Multinationals Corporations (MNCs) for each player group of the air cargo community. The MNC freight forwarders are typically those of the likes of DHL, TNT, and UPS.

The findings of the focus groups were consolidated and an industry validation was applied to ensure that the air cargo community concurred with the reported findings of the focus group discussions. In addition, the findings were compared against the practices of similar air freight supply chains in other countries and locations such as Dubai, Hong Kong, Japan, Schipol, and South Korea. Where necessary, follow- up was done with case participants to verify and confirm the differences among the current set of practices both locally and overseas and for the SME and MNC freight forwarders.

FINDINGS

For this paper, due to the confidentiality of some of the information collected, we report only those data and information made available for public release and dissemination. At the point of writing, a similar study on comparing the current practices between Singapore and Schipol is underway. Hence, the need to ensure confidentiality for part of the findings.

First, we report the findings on the differences between the export processes of the MNC freight forwarders and the SME freight forwarders, which may have a bearing on moving the documentation process to a digital format. From the focus group discussions, this is a key challenge in the adoption of e-freight due primarily to the difficulty in harmonizing all of these differences. The specifics are detailed in Table 1.

	MNC Freight Forwarder	SME Freight Forwarder
Draft House Airway Bill (HAWB)	Shippers often provide shipment details which enable MNC freight forwarders to generate final HAWB	Common practice for SME freight forwarders to generate draft HAWB (since bookings received are usually incomplete e.g. no weight and dimension data) and forward it to shipper for verification.
Cargo Space contracts	Maintain annual cargo space contracts with airlines (based on volume per month)	Booking of cargo space is done on an ad-hoc basis since SMEs do not receive enough volume from shippers
Transportation	Most freight forwarders outsource their transportation activities to 3PLs or transporters	Shipper delivers goods to the freight forwarder's warehouse or freight forwarder owns transportation
Specialization	Each step in the process is managed by a dedicated team (Booking team) trained in this field (e.g. generate HAWB, permit declaration)	Due to the lack of manpower, some steps in the process are done by the same staff
Consolidation	MNC freight forwarders often do not consolidate cargo since they receive large shipment volumes from shippers	SME freight forwarders often consolidate cargo from different shippers to optimize cargo space
Use of IT	Extensive use of specialized IT packages (e.g. Cyberfreight, AurionPro)	Use of basic IT (Microsoft Office) to prepare freight forwarding documents

Table1: Comparison of export process for MNC and SME freight forwarders

The detailed activity set for export flow process of the MNC and SME freight forwarders are found in Figures 1 and 2 below.

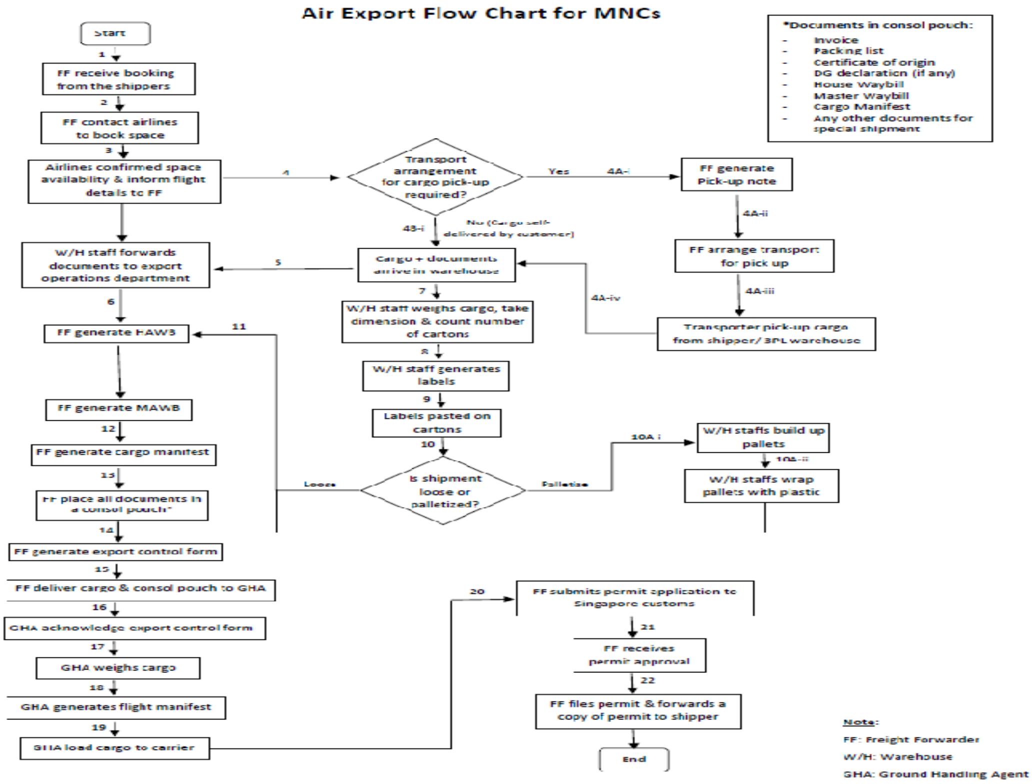


Figure 1: Process of air cargo export for MNC freight forwarders

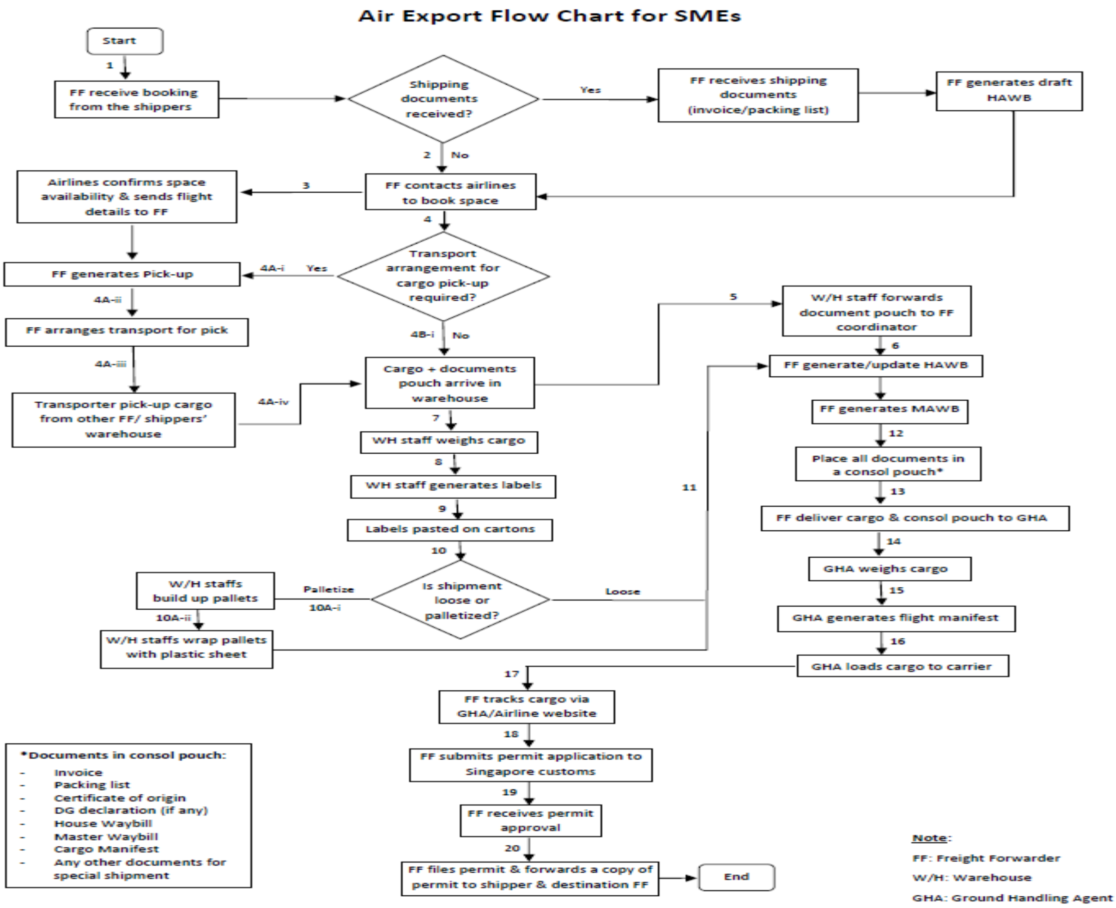


Figure 2: Process of air cargo export for SME freight forwarders

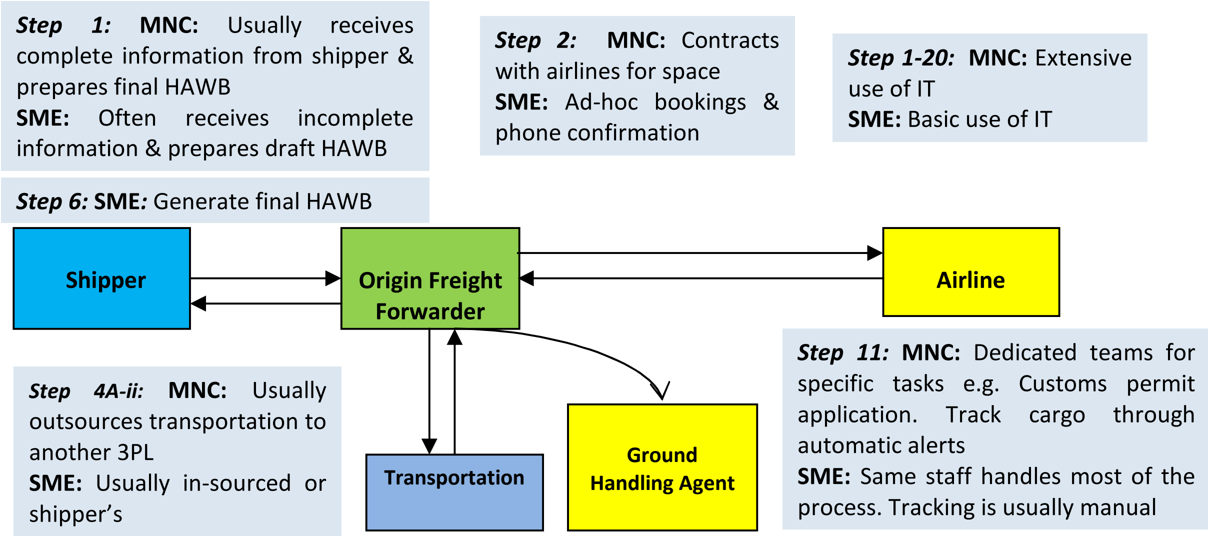


Figure 3: Comparison of SME and MNC freight forwarder export documentation process

Next, when profiling the differences in the export process, the documentation and handling procedures for the different industry sectors were also observed to present a challenge for the eFreight@Singapore initiative. Table 2 highlights some of the sector specific differences.

Chemicals and pharmaceuticals	- Some export raw materials for pharmaceutical products are deemed as dangerous goods and thus need additional paper permits before exporting.
	- Dangerous goods cannot be consolidated with general freight. The paper work has to follow the cargo.
Live fish and plants	- Certificate of Origin (COO) and 'Fish Health Certificate' from AVA are export documents that must accompany the consignments of ornamental fish during import, export or transshipment (where required).
	- Exporters have to apply for Cargo Clearance Permit (CCP) through TradeNet before the shipment is loaded. This delays the clearance time.
Electronics	- Some electronic gadgets such as smartphones do not have an obvious HS code as they can be classified either as computers, phones or cameras. This creates difficulty in harmonising the exports and increases the paperwork.
Automotive and Aerospace	- Batteries and radios are considered as dangerous goods. This again requires additional paper permits before exporting.

Table 2: Sector specific differences for air freight export process

Third, arising from the case study triangulation, in particular those of parts (i) and (ii), we have identified some industry concerns about the acceptance of an electronic documentation platform in the current air cargo export process:

1. Most companies indicate that there is too much data entry involved in the current

air cargo export documentation and opportunities for making mistakes are high. Similar information is entered into different documents as there is no centralized database used by the companies involved in the air transport supply chain. Further, hard copies of documents are normally required at many stages of the air cargo export process when shipping to developing countries.

2. There is too much printing, scanning and sending of physical documents as observed during the site visits to the freight forwarders' offices. The same information is sent to other parties using paper, courier, email, and EDI.
3. Players in the air export process cannot see much significant tangible benefits related to e-freight adoption and some feel that e-freight is beneficial to one or two parties. Even the larger freight forwarders are not really keen to replace their legacy systems with the new initiative.
4. Shippers, especially those with low transaction volumes, are reluctant to use an electronic means of communication. They feel that switching to the e-freight platform (see Table 3) will result in additional cost, re-training of staff, and involve cumbersome processes e.g. tweaking their in-house processes to suit the new system. In the existing cost structure, a freight forwarding company with transaction volumes lower than 400 air freight shipments per month may find it difficult to justify the costs of the electronic transmission of the FWB messages.

General Cargo													
Mandatory cost													
Description		Details	\$/application (SGD)	Air freight shipments per month									
				1	**10**	**100**	**200**	**400**	**600**	**800**	**1,000**	**10,000**
Customs	Statutory Fees	TradeNet	0.9	0.9	9	90	180	360	540	720	900	9,000
Permit	Processing & Transmission Charges	TradeNet	1.98	1.98	20	198	396	792	1,188	1,584	1,980	19,800
Fixed cost for electronic messaging												
CCN Charges	Fixed Message Charge	CCN	300	300	300	300	300	300	300	300	300	300
	Software CCNhub Rental	CCN	285	285	285	285	285	285	285	285	285	285
	Software Host to Host Connection	CCN	350 (FWB<200) 150 (FWB>200)	350	350	350	150	150	150	150	150	150
Variable cost for electronic messaging												
CCN Messaging Charges	Export CMD with FWB	CCN (from freight forwarder)	0.12	0.12	1	12	24	48	72	96	120	1,200
	Neutral Air Waybill	CCN (from freight forwarder)	0.2	0.2	2	20	40	80	120	160	200	2,000
Total				938.2	967	1255	1375	2015	2655	3295	3935	32735
Cost per transaction				938.2	96.7	12.55	6.88	5.04	4.43	4.12	3.94	3.27

Note: 1. CMD refers to the cargo manifest declaration, which as stated in Table 2, is sometimes required in hardcopy and must accompany the cargo.
2. FWB refers to the freight waybill message sent by the freight forwarder for cargo transport.
3. We assume that each air freight shipment involves a transaction on the e-freight platform

Table 3: Cost-benefit analysis of using e-freight

CONCLUSION

This paper has presented an analysis of the e-freight initiative set-up by Singapore to promote the industry-wide use of a digital platform to provide for environmental sustainability in the air freight supply chain. The case study research on the international export documentation process of the air freight sector in Singapore, comprising focus group discussions, site visits, and secondary data, suggests that the business viability of doing so remains very much one of economies of scale. This finding concurs with the Transaction Cost Theory (Sarkis et al., 2011). Clearly, as suggested by Cronin et al. (2011), there is a need to market the initiative to the SME freight forwarders who are driven by cost rather than voluntary action or acceptance of a paperless environment (Arimura et al., 2011). Future work will focus on modeling the carbon footprint of the entire air freight supply chain in moving to a digital platform (Sundarakani et al., 2010), to determine how the cost mechanism can be better engineered for greater cost sharing, thus reaping higher positive externalities for all the stakeholders concerned.

REFERENCES

Arimura, T.H., Darnall, N., Katayama, H. 2011. Is ISO 14001 a gateway to more advanced voluntary action? The case of green supply chain management. ***Journal of Environmental Economics & Management,*** 61(2):170-182.

Arnould, E.J., Wallendorf, M. 1994. Market-oriented ethnography: interpretation building and marketing strategy formulation. ***Journal of Marketing Research***, 31(Nov):484-503.

Cronin, J., Smith, J., Gleim, M., Ramirez, E., Martinez, J. 2011. Green marketing strategies: an examination of stakeholders and the opportunities they present. ***Journal of the Academy of Marketing Science***, 39(1):158-174.

eFreight Monthly Volumes Report. 2011. Retrieved on 19 March 2011 from http://www.iata.org/whatwedo/cargo/efreight/Documents/r17-ef-monthly-volumes.pdf.

eFreight. Retrieved on 17 Jan 2011 from http://www.iata.org/whatwedo/cargo/efreight/Pages/index.aspx.

IATA, 2010. Retrieved on 20 Jan 2011 from http://www.iata.org/pressroom/facts_figures/traffic_results/pages/2010-06-29-01.aspx.

Kreuger, R.A. 1988. ***Focus Groups: A Practical Guide for Applied Research***. London: Sage.

Long Term Market Forecast Summary. Retrieved on 17 Jan 2011 from http://www.boeing.com/commercial/cmo/forecast_summary.html.

Oglethorpe, D., Heron, G. 2010. Sensible operational choices for the climate change agenda. ***International Journal of Logistics Management,*** 21(3):538-557.

Sarkis, J., Zhu, Q., Lai, K. 2011. An organizational theoretic review of green supply chain management literature. ***International Journal of Production Economics,*** 130(1):1-15.

Srivastava, S. K. 2007. Green supply-chain management: A state-of-the-art literature review. ***International Journal of Management Reviews***, 9(1):57-59.

Sundarakani, B., de Souza, R., Goh, M., Wagner, S.M., Manikandan, S. 2010. Modelling carbon footprints across the supply chain. ***International Journal of Production Economics,*** 128(1):43-50.

http://en.wikipedia.org/wiki/Environmental_impact_of_aviation#cite_note-3.

Woodside, A. 2010. ***Case Study Research***. Bingley Emerald Group Publishing.

'BASE' AND 'SURGE' STRATEGIES FOR CONTROLLING ENVIRONMENTAL AND ECONOMIC COSTS IN LOGISTICS TRIADS.

M. M. Naim[1], A. T. Potter[1], V. Sanchez Rodriguez[2] and V. L. Marques[1]
[1]Cardiff University, United Kingdom
[2]Plymouth University, United Kingdom

ABSTRACT
The aim of this paper is to determine the extent to which it is possible to establish a 'base' and 'surge' strategy for logistics provision with a particular emphasis on minimising environmental and economic costs. Our method is the combination of empirical research outputs on the impact of uncertainty on economic and environmental costs, and a synthesis of the literature on resilience and the role of flexibility therein. We find that logistics planners either build contingents into their schedules (a priori) or they respond with contingencies (a posteriori). The former is associated with a 'base' approach; an example of which may be the incorporation of 'slack time' into a schedule to accommodate expected delays due to road congestion. The latter is equivalent to a 'surge' approach where as an example the logistics provider may have capacity flexibility, in the form of acquiring additional vehicles, to accommodate post-plan changes in shipper volume requirements. This paper explicitly rationalises the links between uncertainty, 'base' and 'surge' supply chain strategies, and the strategic use of logistics flexibility, in minimising environmental and economic costs in a logistics triad. The output is in the form of a conceptual managerial feedback control system.

Introduction:

The challenges facing supply chain managers due to uncertainty are well documented (Davis, 1993, Mason-Jones and Towill, 1998, Peck et al, 2003, Van der Vorst and Beulens, 2002). Only recently has the concept been extended to focus specifically on the impact of uncertainty on logistics operations (Sanchez Rodrigues et al, 2008).

In meeting the challenges afforded by uncertainty, strategies adopted may potentially lead to increased costs in the supply chain. More specifically 'base' (lean) and 'surge' (agile) manufacturing strategies have been advocated as ways to cope with demand uncertainty (Christopher and Towill, 2001, Christopher and Towill, 2002). Hence, manufacturing companies in the supply network will typically either aim to track the variations by creating a 'surge' in capacity, hence leading to increased production on-costs, or else buffer themselves against such variations through inventory which, although ensuring a level or 'base' capacity requirement, increases the risk of stock holding and obsolescence costs. More recently, empirical research on logistics operations has shown that uncertainty leads to increases in both economic and environmental costs (Sanchez Rodrigues et al, 2010c).

The aim of this paper is to develop a model that incorporates 'base' and 'surge' strategies to accommodate the particular characteristics of uncertainty associated with logistics provision. More specifically, the model is to be in the form of a management feedback system that focuses on minimising environmental and economic costs.

Logistics uncertainty:

Sanchez Rodrigues et al (2008) have undertaken a synthesis of the literature on supply chain uncertainty from which they have developed an uncertainty model focussing specifically on freight transport operations. The model may be conceptualised as in Figure 1 which highlights the areas where uncertainty may occur; anywhere in the logistics triad (customer, supplier or carrier) control systems and the external environment. The model of Figure 1 has subsequently been tested via focus groups and a survey with participation from practitioners and policy makers (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b).

The uncertainty model of Figure 1 focuses on the logistics triad, arguably the minimum unit of analysis for any supply chain study (Beier, 1989, Naim et al, 2006). Pertinent to the logistics triad is the concept that the carrier is an integral member of the supply chain (Stank and Goldsby, 2000). By considering the logistics triad it is then possible to consider the value adding nature of freight transport that contributes to the overall performance of the supply chain and in delivering customer value (Mason and Lalwani, 2006).

It is often seen that freight transport operations have to be flexible in responding to uncertainties so as to ensure effectively delivery of goods (Narus and Anderson, 1996, Boughton, 2003) while at the same time minimising the impact of transport on economic and environmental costs (Duclos et al., 2003). The offering of flexibility has often been as a result of the commoditisation of freight transport with carriers adopting a reactive "one size fits all" strategy to logistic provision (Bask, 2001,). The result is a potential dichotomy in attempting to achieve flexibility and cost reduction.

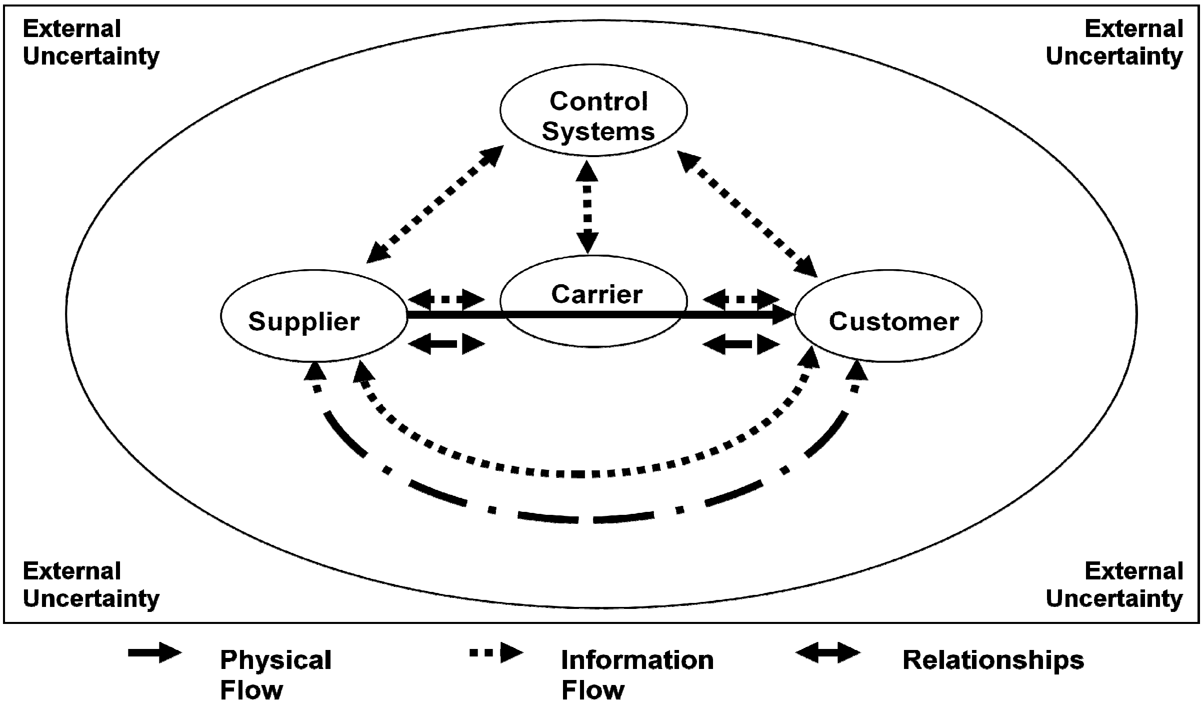


Figure 1: The logistics triad uncertainty model (Sanchez Rodrigues et al, 2008)

Naim et al (2006) suggest that a proactive strategy, where different flexibility types are considered, is a more effective way for carriers to deliver value in the supply chain. Based on a synthesis of the existing literature they highlight a number of generic flexibility capabilities that carriers should consider when offering their services;

- Mode flexibility — Ability to provide different modes of transport
- Fleet flexibility — Ability to provide different vehicle types to carry different goods
- Vehicle flexibility — Ability to configure vehicles to carry products of different types or to cater for different loading facilities
- Node flexibility — Ability to plan, approve and implement new nodes in the network
- Link flexibility — Ability to establish new links between nodes
- Temporal flexibility — Ability to sequence infrastructure investment and the degree to which the use of such infrastructure requires coordination between users
- Capacity flexibility — Ability of a transport system to accommodate variations or changes in traffic demand
- Routing flexibility — Ability to accommodate different routes
- Communication flexibility — Ability to manage a range of different information types

Method:

The research underpinning this paper follows the overall process as given in Figure 2. The conceptual model is as given in Figure 1 (Sanchez Rodrigues et al, 2008) which has been tested through opinion based methods such as focus groups and surveys (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b). A number of empirical case studies have been undertaken which have been analysed in terms of the impact of uncertainty on freight transport costs and CO_2 equivalent emissions (e.g. Sanchez Rodrigues et al, 2010c).

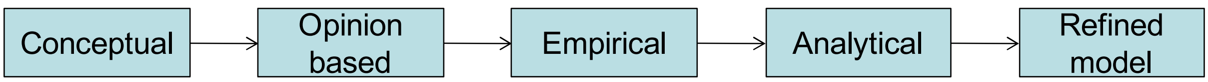


Figure 2: Development of the logistics triad uncertainty model

This paper focuses on the last stage of the research process wherein we take the results of the preceding stages and close the loop back to the body of literature in order to extend the logistics triad uncertainty model. In particular we interrogate the freight transport flexibility types developed by Naim et al (2006) to show which are most relevant to a 'surge' and 'base' response to uncertainty. We also explore the literature on supply chain resilience with the view to the establishment of a final refined model in the form of a management feedback system.

Analysis and Findings:

Opinion based research (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b) identifies the expectations of stakeholders to the likely causes of uncertainty in the logistics triad. The biggest expected uncertainly is a delay with the most dominant being due to road congestion. Road congestion is an external uncertainty source that in the main is mostly predictable based on the time of day that road journeys are undertaken. With routeing algorithms, carriers can accommodate the expected delays into their planned schedules. When unexpected events, such as road traffic accidents, do occur their occurrence can be mitigated by the application of satellite navigation systems that enable alternative routes to be sought.

The second biggest issue emerging from the opinion based research was the uncertainty due to changing demand from customers. Demand tends to be highly volatile with unexpected short-notice additional transport requirements or cancellations of previously agreed loads. This volume volatility can be exacerbated by poor information visibility can which reduces demand accuracy, increases safety stock levels at the shipper and increases the number of unnecessary transport movements. The lack of demand accuracy can have a knock-on effect on the volatility of transport volume requirements.

In empirical case based research Sanchez Rodriguez et al (2010c) evaluate the impact of uncertainty in the logistics triad on economic and environmental costs. They found that uncertainty led to two phenomena, which they term as 'extra distance' and 'extra time'. 'Extra distance / extra time' may be defined as any non value-added or unnecessary distance / time within a distribution network due to supply chain uncertainty, and defined as the difference between the distance/time vehicles actually ran, and the distance/time they would have needed to have run if:

- the transport operation had received accurate and timely information on the volumes to be moved, and/or
- there had been no unexpected delays at loading or unloading points and/or
- there had been no operational failures within the distribution network and/or
- there had been no congestion on the journey that could not have been foreseen

'Extra distance' has the potential to increase fuel usage leading to increased costs and engine emissions while 'extra time' leads to unnecessary additional slack time built in the schedules hence not fully utilising the vehicle resources available.

Observations were undertaken of a FMCG secondary distribution operation based in the UK (Sanchez Rodrigues et al, 2010c). Observations included interrogating the vehicle routing and scheduling (VRS) system used to optimise, track and trace, and re-optimise transport movements. In addition, discussions with planners and managers were undertaken to corroborate and elaborate on the interpretation of data from the VRS system. The data of interest for our paper is shown in the first two columns of Table 1; the 'extra distance / time' types and the causes of uncertainty. In the other columns we include some description of each 'extra distance / time' type as well as the mitigations approaches used by the planners.

The mitigation approaches we have classified as 'a priori' and 'a posteriori', and we have related them to 'base' and 'surge' strategies respectively. In the 'a priori' category, there is potentially sufficient information available before the event that causes the uncertainty. We note what was actually done (for the case of route diversion) and, in italics, what the planners believed could be done if the information was made available, enabled via communication flexibility (for the cases of load more than advised and products not loaded). In the 'a posteriori' case action can only be taken after the event and we note in Table 1 what was actually actioned by the planners and relate such actions to capacity, communication, fleet and routing flexibilities.

The observations of Table 1 are synonymous the training guidelines developed for the United States of America military logisticians (Brecke and Garcia, 1995, 1998). Logistics decision making, as that undertaken by logistics planners, is a temporal activity and is dependent on a critical path timeline. We redraw their generic timeline as Figure 3 which is modified to encapsulate the type of uncertainties and mitigations we have defined in Table 1.

The Start Point, SP, equates to any event, or uncertainty cause, that disrupts the logistics operation. The Recognition Phase is that time during which the planner is aware of the event occurring. The planner can be said to have 'sensed' the occurrence of the event by the Recognition Point, RP. The planner then has a Decision Window, DW, by which to seek alternative courses of action during the Uncertainty Reduction Phase before he makes a decision at the Decision Point, DECP and starts the Implementation Phase at the Default Point, DEFP.

Extra distance/time types	Uncertainty causes	Description	A posteriori 'surge' mitigation	A priori 'base' mitigation
Extra distance/time due to route diversion	Road restrictions	Extra distance needs to be run in an attempt to minimise the delay to the trip. But this may not always be possible and hence extra time generated.	Routing flexibility to accommodate re-routeing. Communication flexibility to utilise GPS and re-routing software.	'Extra time' built into the plan when it is known that at certain times of the day there is likely to be delays e.g. rush hour or evening curfews
	Unplanned Road Congestion			
Extra distance/time due to delays	Store	Delays may occur, e.g. due to slow (un)loading at stores/ suppliers. This could incur an additional vehicle due to the vehicle originally assigned to the trip may not arrive at destination on time.	Capacity flexibility to accommodate variations or changes in traffic demand. Routing flexibility to get around delays.	
	Suppliers			
	Unplanned stops			
	Unplanned Road Congestion			
Extra distance/time due to load more than advised	Late notification of extra volume from stores	The originally planned vehicle size is not appropriate and hence additional vehicle are need to accommodate a higher volume.	Capacity flexibility to accommodate variations or changes in traffic demand. Link flexibility to allow vehicles to be sourced from other flows.	*Advanced notice of changes in planned volume. Communication flexibility required to accommodate new sources of information.*
	Late notification of extra volume from suppliers			
Extra distance/time due to inappropriate vehicle size	Technical vehicle failure	Original vehicle not available for departure and may be substituted by a number of smaller sized vehicles.	Capacity flexibility and Fleet flexibility to provide different vehicle types.	
Other	Product not loaded at distribution centres	Volume accumulates for the next day and this product ultimately needs to be moved which may lead to late notification of extra volume.	Capacity flexibility to accommodate variations or changes in traffic demand. Routing flexibility to ensure full vehicle loads.	*Advanced notice of missed additional products. Communication flexibility required to accommodate new sources of information.*
	Product not loaded at suppliers			

Table 1: Empirical data analysis

It may be concluded that DW defines the time which it takes for the logistics operation respond to the Event and by DEFP the logistics operations have recovered. We may postulate that how well and quickly that recovery is achieved is dependent on the inherent flexibilities of the logistics triad, or how ready is the logistics triad in responding to uncertainty. There is also a feedback phase where the lessons learnt from the actions undertaken are utilised by planners in preparing for the next possible event.

Approaches that detect and manage, or sense and respond, to unplanned or abnormal occurrences is well known in the literature (Haeckel and Nolan, 1993) with examples of its implementation again coming from military logistics (Tripp et al., 2006).

In addition, we find analogue between our research findings and supply chain resilience (for example, Christopher and Peck, 2004, Sheffi and Rice Jr, 2005). Ponomarov and Holcomb (2009) define supply chain resilience as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations".

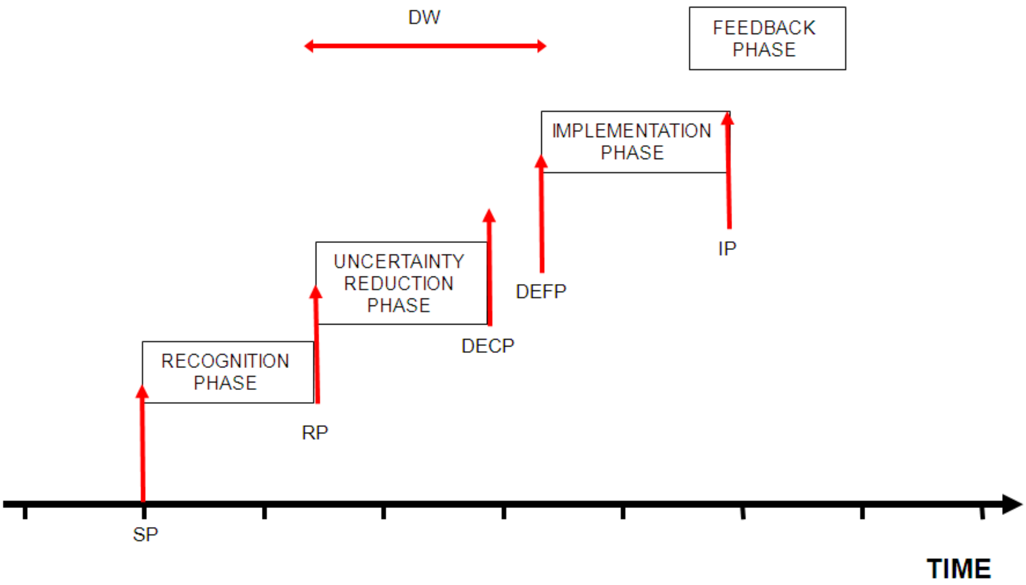
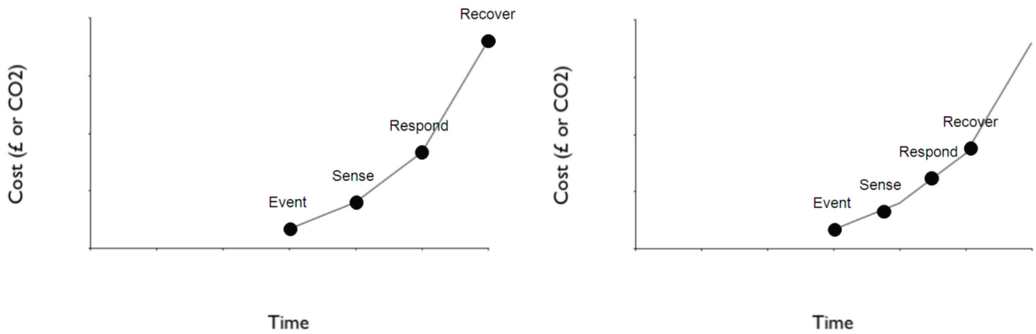


Figure 3: The logistics planner's decision timeline

The supply chain resilience literature encapsulates the concepts of readiness, response, and recovery. With consideration of Figure 3 and with the inclusion of the concept of sensing we may define logistics resilience as;

a) Readiness: before SP, the logistics triad is prepared for uncertainty or a disruptive event through the development of freight transport flexibility capabilities at a reasonable cost.
b) Sensing: minimising the lag between the event occurring and the logistics triad's recognition of the event, RP, ensures the number of options available to planners is maximised.
c) Response: reaction to a specific event is given by DW. A quick and flexible response implies minimising the time to react to the disruptions and begin the recovery phase.
d) Recovery: a return to normal stable or steady state conditions, by the implementation point, IP

The implications of developing adequate flexibility types on resilience are as given in Figure 4, which is a development of Bodendorf and Zimmerman (2005) who used similar curves to highlight the benefits of an electronic disturbance detection system. Hence, the sooner an event occurs, the more options that are available to a planner for corrective action, and hence the possibility of finding a better course of action in the time available increases. Thus costs may be minimised.



(a) (b)

Figure 4: The benefits of resilience – (a) without resilience, (b) with resilience

Much of the above discussion concerns the 'a posteriori' actions after an event has occurred. But as we noted in Table 1, with the two cases where 'a posteriori' actions are the norm, facilitating communication flexibility would enable 'a priori' actions to be taken. In such a situation we would then find that the cost curves shown in Figure 4 will become as shown in Figure 5.

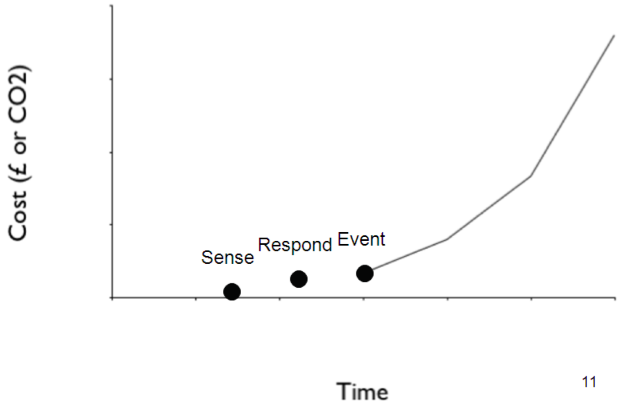


Figure 5: Benefits of enhanced communication flexibility leading to 'a priori' knowledge

Achieving the cost curve in Figure 5 will require information visibility in the logistics triad. Empirical observations have noted that while additional loads, and in many cases volume changes, are known well in advance by suppliers, stores or distribution centres, these are often not communicated in time for the logistics planner's 'a priori' schedule. Hence, a simple action, observed in another case (Naim et al, 2009) would be to ensure that such information is transferred immediately and directly to the logistics planner, thereby increasing communication flexibility.

Bringing all the elements of the findings together, we may then develop a management feedback control system as shown in Figure 6. Sensing events, through real-time data collection, is a critical element of the system, whether it be for 'a priori' or 'a posteriori' decision making.

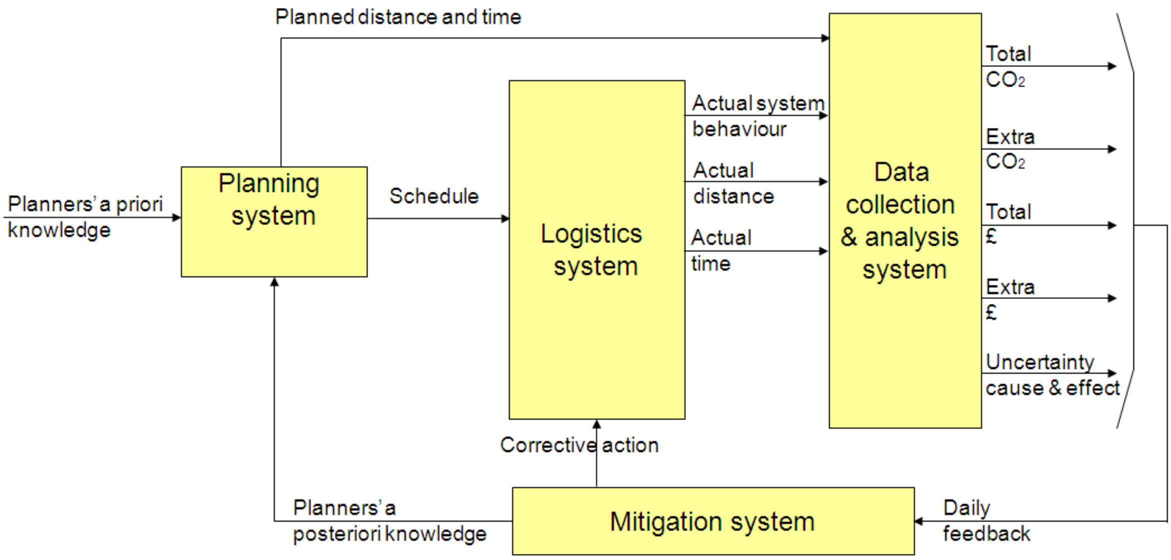


Figure 6: Management feedback control system to minimise extra distance / time

Notable in the case research (Sanchez Rodrigues et al, 2010c) is the lack of appreciation of the impact of extra distance / time which may yield increased additional economic and environmental costs. Over a year, in a large logistics network, that may equate to £1 million and 500 tonnes of CO_2.

Conclusion:

We find that logistics planners either build contingents into their schedules (a priori) or they respond with contingencies (a posteriori). The former is associated with a 'base' approach while the latter is equivalent to a 'surge' approach. The logistics triad may achieve enhanced resilience through the development of freight transport flexibilities. In particular, within the context of a management feedback control system, communication flexibility will enhance the ability to sense and respond 'a priori' to an event.

REFERENCES:

Bask, A., 2001, Relationships among TPL providers and members of supply chains: a strategic perspective, Journal of Business and Industrial Marketing, 16(6) 470–486.

Beier, F., 1989, Transportation contracts and the experience effect: a framework for future research, Journal of Business Logistics, 10(2) 73-89.

Bodendorf, F. and Zimmerman, R., 2005, Proactive supply chain event management with agent technology, International Journal of Electronic Commerce, 9(4) 57-89.

Boughton, R.F., 2003, Addressing the escalating cost of road transport, Logistics and Transport Focus, 5(3) 36-43.

Brecke, F.H. and Garcia, S.K, 1995, "Training methodology for logistics decision making", Report AL/HR-TR-1995-0098, Air Force Materiel Command, Brooks Air Force Base, Texas.

Brecke, F.H. and Garcia, S.K, 1998, "Desktop training for decision makers", Report AL/HR-TR-1997-0045, United States Air Force Research Laboratory.

Christopher, M. and Towill, D.R., 2001, An integrated model for the design of agile supply chain, International Journal of Physical Distribution and Logistics Management, 31(4) 235-246.

Christopher, M. and Towill, D.R., 2002, Developing market specific supply chain strategies, International Journal of Logistics Management, 13(1) 1-14.

Davis, T., 1993, Effective Supply Chain Management, Sloan Management Review, Summer, pp. 35-46.

Duclos, L.K., Vokurka, R.J. and Lummus, R.R., 2003, A conceptual model of supply chain flexibility, Industrial Management & Data Systems, 103(6) 446-56.

Haeckel, S. H., & Nolan, R. L. 1993. Managing by wire. Harvard Business Review, 71(5), 122-132.

Mason, R. and Lalwani, C., 2006, Transport integration tools for supply chain management, International Journal of Logistics: Research and Applications, 9(1) 57–74

Mason-Jones, R. and Towill, D.R., 1998, Shrinking the supply chain Uncertainty Circle, Control, September, pp. 17-22.

Naim, M. M., Aryee, G. and Potter, A., 2010, Determining a logistics provider's flexibility capability, International Journal of Production Economics, 127(1) 39-45

Naim, M.M., Potter, A.T., Mason, R.J. and Bateman, N., 2006, The role of transportation flexibility in logistics provision, The International Journal of Logistics Management, 17(3) 297-311.

Narus, J.A. and Anderson, J.C., 1996, Rethinking distribution: adaptive channels, Harvard Business Review, 74(4) 112-20.

Peck, H., Abley, J., Christopher, M., Haywood, M., Saw, R., Rutherford, C. and Strathen, M., 2003, Creating Resilient Supply Chains: A Practical Guide. Cranfield University, Cranfield, Bedford).

Ponomarov, S.Y. and Holcomb, M.C., 2009, Understanding the concept of supply chain resilience, International Journal of Logistics Management, 20(1) 124–143.

Sanchez Rodrigues, R. V., Potter, A. T. and Naim, M. M., 2010a, Evaluating the causes of uncertainty in logistics operations, International Journal of Logistics Management, 21(1) 45-64.

Sanchez Rodrigues, R. V., Potter, A. T. and Naim, M. M., 2010b, The Impact of Logistics Uncertainty on Sustainable Transport Operations, International Journal of Physical Distribution and Logistics Management, 40(1/2) 61-83.

Sanchez Rodrigues, V., Potter, A., Naim, M., McKinnon, A. and Darby, J., 2010c, Measuring the time and distance impact of transport uncertainty: a FMCG case study, Logistics Research Network Conference, Harrogate, 8th-10th September, 606-615.

Sanchez Rodrigues, V., Stantchev, D. S., Potter, A. T., Naim, M. M. and Whiteing, A. E., 2008, Establishing a transport operation focussed uncertainty model for the supply chain, International Journal of Physical Distribution and Logistics Management, 38(5) 388-411.

Sheffi, Y. and Rice, J.B., 2005, A supply chain view of the resilient enterprise, MIT Sloan Management Review, 47(1) 41–48.

Stank, T.P. and Goldsby, T.J., 2000, A framework for transportation decision making in an integrated supply chain, Supply Chain Management: An International Journal, 5(2) 71-77.

Tripp, R. S., Amouzegar, M. A., McGarvey, R. G., Bereit, R., George, D., & Cornuet, J. 2006. Sense and Respond Logistics Integrating Prediction, Responsiveness, and Control Capabilities: Rand.

Van der Vorst, J. and Beulens, A., 2002, Identifying sources of uncertainty to generate supply chain redesign strategies, International Journal of Physical Distribution & Logistics Management, 32(6) 409-430.

GREEN SUPPLY CHAINS: AN INDIAN PERSPECTIVE

Samir Dani
School of Business and Economics, Loughborough University, Loughborough, UK

ABSTRACT
In today's business environment global supply chains have to deal with the complexities of sourcing, logistics and costs. In order to keep costs down, supply chains are long and thus have to deal with complex inventory management challenges. Another challenge faced by supply chains is that of being environmentally friendly or green. As the discussion regarding climate change gathers momentum, the supply chains will be held under scrutiny for carbon emissions and use of fuel. Green supply chains are designed to be environmentally friendly from the raw material phase to product disposal. This paper considers the Indian perspective with regards to green supply chains and questions the barriers and enablers for implementing green supply chains in India. The study is exploratory and utilises desk research and a short survey.

INTRODUCTION
Global supply chains operate with the aim to source products for customers and shareholders at the cheapest prices and good quality. For this, supply chain designs will account for being further away from the point of consumption. This however leads to a trade-off between polluting the planet and providing value to the customer. Barcoding, RFID tagging, individual packaging according to customer needs, commoditisation, mass customisation, etc are some of the practices which provide increased revenues but can lead to environmental pollution. Higher carbon emissions, reduced fresh water availability, increased temperatures and inherently a change in climatic conditions have introduced a challenge to the supply chain community to innovate practices and reduce energy consumption and waste in order to meet sustainability requirements. Hence, the assumption is that future supply chain designs will inculcate these new characteristics. Sustainability, Green and Ethical purchasing are the important factors affecting next generation supply chains (Vachon and Klassen, 2006). Since India provides an important outsourcing location both for manufacturing and services, it is pertinent to investigate the propagation of "green factors" within the supply chain design. As exporters Indian companies will need to in the near future start changing their practices to bring in more "green credentials", starting with supply chain management.

GREEN SUPPLY CHAINS
According to Srivastava (2007), green supply chain management consists of introducing green or environmental principles into supply chain management. This could be possible through product design, material sourcing and selection, manufacturing, delivery and reverse logistics. Zsidisin and Siferd (2001) defined green supply chain management as the "set of supply chain management policies held, actions taken and relationships formed in response to concerns related to the natural with regards to design, acquisition, production distribution, re-use and disposal". It is important to note that greening the supply chain will need a radical think of how the supply chain is configured and governed. Hervani et al (2005) and Walker (2008) discuss green supply chains and suggest that the chain covers all processes from raw material procurement to disposal taking into the account the product lifecycle. Vachon and Klassen (2006) suggest that due to the lack of consensus in the supply chain literature, it is difficult to have a clear unified framework for green supply chains. Bowen et. al (2001) has defined green supply as the purchaser's intent to improve the environmental performance of the supplier and/ or product. Green supply chains not only consider the processes but also try to reduce fuel and energy use. Green supply chains have strict performance criteria and they also have to work within national and international regulatory compliance with regards to carbon emissions, toxic waste and product disposal. A literature search revealed only a couple of academic publications catering towards green supply chain management within the Indian context

(Mudgal, et al, 2009, 2010; Flores, 2008). This paper explores the enablers and barriers that affect green supply chains in India. The research questions are:

RQ1. What are the barriers to Greening the Supply Chain within the Indian context?
RQ2. What are the enablers to Greening the Supply Chain within the Indian context?
RQ1. Does Green Supply Chains have an impact on the Indian business environment?

RESEARCH METHODOLOGY

The paper presents a new area of work and hence the methodology at the outset is to be exploratory in nature. A literature review considers the issue through various viewpoints and assimilates a better understanding of the research questions. Secondary data through cases is analysed to get a practical insight into current problems. The research is conducted in two stages. The first stage is desk research which comprises of an extensive literature review using journal publications, professional magazine articles, and published case information. This stage provides insight into the research questions. The second stage consists of a survey questionnaire deployed to supply chain practitioners electronically via surveymonkey. The data from the two stages is analysed to arrive at an understanding of green supply chains in India. This research tries to provide an insight for the research questions. In doing so, it identifies the variables that will influence green supply chain implementation in India.

ANALYSIS AND FINDINGS

The literature review and the survey have identified the barriers and enablers for green supply chains. In the Indian context it is difficult to implement green supply chains as this is a relatively new concept within the Indian business environment. Due to the global nature of today's supply chains, Indian companies feature quite prominently within the structure of global supply chains. Hence, it is important for these Indian companies to meet the green credentials of today's multinational supply chains.

Barriers and Enablers of green supply chains

Green supply chains are a part of a cultural change within the field of supply chains. To implement green supply chains certain enablers are required to be present within the business environment. There are more barriers than enablers, however if these barriers can be identified it will a good starting point to facilitate implementation of green principles within the supply chain.

Walker, et. al. (2008) has identified the barriers and drivers for an environmental supply chain. The authors have identified the barriers as: Internal barriers (costs, lack of training, lack of understanding green initiatives) and External barriers (regulation, poor supplier commitment and industry specific barriers). Ravi and Shankar (2005) have studied the Indian automotive sector with regards to reverse logistics and have identified barriers for it. These are identified as: lack of information and technological systems, problems with product quality, company policies, resistance to change, lack of appropriate performance measures, lack of training, financial constraints, lack of commitment from top management, lack of awareness and reluctance from supply chain partners.

When discussing about green supply chain management Bowen et. al. (2001) state that organisations will adopt green supply chain management only if they can identify specific operational and financial benefits. They also have internal drivers for implementing green supply policies (strategic purchasing and supply, corporate environmentally proactivity, and supply management capabilities. Walker et al. (2008) have identified the drivers for green supply chains, Internal drivers (organisation factors), external drivers (regulation, customers, competitors, society and suppliers). Lee (2008) identified the main drivers as and green supplier buyer influence, government involvement and green supply chain readiness. Diabat and Govindan (2010) discuss enablers and barriers.

Responses from industry
A survey questionnaire was created using 'surveymonkey'. The link to this questionnaire was emailed to a sample of 12 senior managers in India. These managers had on a previous occasion attended a supply chain workshop that the researcher was a part of. The link was also posted on to an Indian supply chain group on 'Linkedin, however this did not generate any new data. Of the 12 respondents 9 filled in the questionnaire completely. The data from the 3 incomplete questionnaires was not considered for analysis. The data is insufficient for statistical analysis, however it provides a good exploratory insight as the managers represent senior level in India and can be assumed to have a strategic focus. However, one limitation of the survey is that these responses may be valid only for this dataset as it is small number of responses.

Referring to figure 1, it can be seen that of the 8 companies out of the 9 are currently involved in green initiatives. These include initiatives such as

'*creating energy efficient products, having an organisational Environment policy, working on creating a reliable source of clean energy to power the production plant, sustainable farming practices, sustainable packaging, reducing carbon footprint by ways of reducing emissions from the products, reduce power consumption, producing recyclable parts/accessories, energy conservation and rain water harvesting'*

These initiatives range from organisational level initiatives to reduce energy use to creating green products. There are some broader social initiatives too.

Another positive aspect is that 7 out of the 9 companies have some sort of a proactive process to conduct green initiatives. 2 companies have dedicated teams whereas 5 companies have a team comprised of members from various functions within the company. Only 2 companies said that they do not have a proactive team looking at green challenges but will form a team as when required. This is represented again when looking at green initiatives across the supply chain and 7 out 9 companies have said that they work actively with partners in the supply chain to implement green initiatives.

Is your current organisation involved in any green initiatives?		
Answer Options	**Response Percent**	**Response Count**
Yes	88.9%	8
No	11.1%	1
Details		5

Does your organisation have a functional team looking at CSR and green initiatives?		
Answer Options	**Response Percent**	**Response Count**
Yes, a full time team	22.2%	2
Yes, a team of members from other departments	55.6%	5
No, we use external consultants to guide us.	0.0%	0
No, we handle green issues as an when they happen	22.2%	2
Other (please specify)		1

Does your organisation work actively with the suppliers or distributors to implement green initiatives?		
Answer Options	**Response Percent**	**Response Count**
Yes	77.8%	7
No	22.2%	2

Fig 1: Involvement of Indian companies in green practices

Figure 2, presents the barriers to implementing green supply chains within India. The barriers identified as the most important are related to training and information needs. The barriers are: *Lack of knowledge regarding green initiatives, Lack of training to implement green initiatives, Lack of knowledge regarding international legislation, Lack of buyer awareness about green, Lack of company policies regarding green, Lack of green supplier network.* There are other barriers but it seems that the major hurdle is **lack of knowledge and inclination to go green**.

Figure 3, presents the enablers for implementing green supply chains within India. Most of the respondents have identified the items presented in the survey as important enablers for implementing green supply chains in India. The two most significant are: **pressure from the markets for green products** and change of perspective- **being green will provide a competitive advantage in the long term.** This also supports the view that there is a need to have a green supplier network and sufficient knowledge regarding international regulations on green.

Figure 4, presents a perspective from the respondents on how they think the Indian business environment will change in case green supply chains were implemented. The respondents think that there will be an increased effort in the Indian business community to **reduce energy, reduce waste and reduce carbon emissions**. The results also suggest that the Indian business environment will actively think about the interaction of the business environment with the social environment.

It is difficult to implement Green Supply chain Management in India due to the following reasons: (Please tick whether you agree or disagree for each factor)							
Answer Options	**Strongly Disagree**	**Disagree**	**Maybe**	**Agree**	**Strongly Agree**	**Rating Average**	**Response Count**
It is not cost effective	0	3	1	**4**	1	3.33	9
Does not provide the appropriate Return on Investment	0	3	1	2	**3**	3.56	9
Lack of company policies towards green initiatives	0	1	1	**5**	2	3.89	9
Lack of resources	1	0	3	4	1	3.44	9
Lack of performance metrics	0	0	3	4	2	3.89	9
Lack of knowledge regarding green initiatives	0	1	1	**5**	2	3.89	9
Lack of training to implement green initiatives	0	0	2	**5**	2	4.00	9
Lack of knowledge regarding International legislation	0	0	1	4	**4**	4.33	9
Lack of management commitment	0	1	0	**6**	2	4.00	9
Lack of buyer awareness regarding green	0	0	2	**6**	1	3.89	9
Lack of a green supplier network	0	0	2	2	**5**	4.33	9
Lack of appropriate national legislation	0	0	3	3	3	4.00	9
Lack of reverse SC initiatives	0	0	3	**5**	1	3.78	9
Lack of reverse SC infrastructure	0	0	3	**5**	1	3.78	9
Lack of Societal requirements for green initiatives	0	0	4	2	3	3.89	9
Any other barriers- please specify							1

Fig 2: Barriers to Green Supply Chain management in India

Green Supply chain Management can be implemented in India if the following was done: (Please tick whether you agree or disagree for each factor)							
Answer Options	Strongly Disagree	Disagree	Maybe	Agree	Strongly Agree	Rating Average	Response Count
Pressure from the markets to buy green products	0	0	1	6	2	4.11	9
Pressure from society for organisations to go green	0	0	3	5	1	3.78	9
Introduction of a national green regulatory compliance	0	0	3	3	3	4.00	9
Organisations focus on CSR activities on moral grounds	0	1	4	3	1	3.44	9
Better training to employees regarding green initiatives	1	0	3	4	1	3.44	9
Better coordination with the supply chain partners to implement green initiatives	0	1	1	6	1	3.78	9
Change of perspective- gaining competitive advantage by going green	0	1	0	5	3	4.11	9
Clear performance metrics	0	0	3	5	1	3.78	9
Better knowledge about International regulations	0	0	2	6	1	3.89	9
Any other barriers- please specify							0

Fig 3: Enablers to Green Supply chain management in India

Green Supply chain Management will have an effect on the Indian Business Environment: (Please tick whether you agree or disagree for each factor)							
Answer Options	Strongly Disagree	Disagree	Maybe	Agree	Strongly Agree	Rating Average	Response Count
There will be more Corporate Social Responsibility initiatives	1	0	3	3	2	3.56	9
More thought regarding the interaction of the business environment with society	0	0	2	**7**	0	3.78	9
Change in organisational governance structures and mission statements	0	2	1	**5**	1	3.56	9
Thinking proactively regarding how the organisational operations affect climate change	0	1	2	**6**	0	3.56	9
Increased Innovation capability for green products and processes	0	0	3	**4**	**2**	3.89	9
Increased effort to reduce carbon emmissions	0	1	0	**8**	0	3.78	9
Increased effort to reduce energy use	0	1	0	**5**	**3**	4.11	9
Increased effort to reduce waste within product offerings Increased effort to reduce waste within business operations	0	1	0	**5**	**3**	4.11	9
Any other barriers- please specify							0

Fig 4: Effect of green supply chains on the Indian Business Environment

CONCLUSION AND FUTURE SCOPE

The research has identified the current perspectives with regards to green supply chains within the Indian context. The paper has presented the barriers and enablers to green supply chain implementation both from literature sources and from a short survey conducted with professionals in India. The results have suggested that the barriers are an effect of lack of knowledge and training of green initiatives and implementation processes. The results also suggest that green supply chain implementation can be possible if the customers start asking for green products. Currently, the Indian market (both industrial and consumer) are not very green in their outlook and also the Indian producers do not consider that being green can provide them with a competitive advantage. If the Indian producers are required to adhere to international regulation with regards to green measures, it will be important for the Indian supply chain to implement green measures. It is also quite logical to think that once the need to implement green initiatives arises it will have a profound effect on how business in conducted in India. The results of the short survey suggests that respondents who represent industry feel that there will be an increased focus on reducing energy, waste and carbon emissions. There will be a more proactive approach towards green implementation. One of the limitations of this research has been the size of the survey sample. Although it does provide some good insight, the sample is insufficient for a statistical analysis. In the future, the survey should be conducted for a larger sample. Also, as future work the variables for the barriers and enablers should be tested for correlation.

REFERENCES

Bowen FE, Cousins PD, Lamming RC, Faruk AC. (2001) The role of supply manage- ment capabilities in green supply. Production and Operations Management; 10(2):174–89.

Diabat A, Govindan K. (2011) Analysis of the drivers affecting the implementation of green supply chain management. Resour Conserv Recy, doi:10.1016/j.resconrec.2010.12.002

Flores, M., Boer, C., Canetta, L., Pouly, M., Cherian, M. (2008) Critical Success Factors and Challenges to develop new Sustainable Supply Chains in India based on Swiss Experiences, 14th International Conference on Concurrent Enterprising, Costa da Caparica, Lisboa, Portugal, 23-25 June, 2008

Hervani AA, Helms MM, Sarkis J. (2005) Performance measurement for green supply chain management. Benchmarking: An International Journal, 12(4):330–53.

Lee S-Y.(2008) Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. Supply Chain Management: An International Journal;13 (3):185–98.

Mudgal, R, Rakesh K. Ravi Shankar, Talib, P., Tilak Raj (2010) Greening the supply chain practices: an Indian perspective of enablers' relationships, International Journal of Advanced Operations Management 2009 - Vol. 1, No.2/3 , pp. 151 - 176

Mudgal, R, Rakesh K. Ravi Shankar, Talib, P., Tilak Raj (2010) Modelling the barriers of green supply chain practices: an Indian perspective, International Journal of Logistics Systems and Management, Volume 7, Number 1 / 2010 , pages: 81 - 107

Ravi V, Shankar R. (2005) Analysis of interactions among the barriers of reverse logistics. International Journal of Technological Forecasting & Social change;72(8):1011–29.

Srivastava, K S. (2007) Green supply-chain management: A state-of-the-art literature review. International Journal of Management Reviews, 9(1):53–80

Vachon, S.,Klassen, R.D. (2006) Extending green practices across the supply chain, International Journal of Operations & Production Management, Vol. 26 No. 7, pp. 795-821

Walker H, Di Sisto L, Mc Bain D (2008) Drivers and barriers to environmental supply chain
Management Practices: Lessons from the public and private sectors, Journal of Purchasing and supply Management 8;14 (1):69–85

Zsidisin G A, Siferd S P. (2001) Environmental Purchasing: A Framework For Theory Development. European Journal Of Purchasing And Supply Management, (1):61–73.

SECTION 8 – OUTSOURCING AND CUSTOMER-SUPPLIER RELATIONSHIP MANAGEMENT

A MATHEMATICAL INVESTIGATION OF ALTERNATIVE FORMS OF SUPPLIER DEVELOPMENT

Christoph H. Glock[1], *Mohamad Y. Jaber*[2], *Alfred L. Guiffrida*[3]

[1] Chair of Business Management and Industrial Management, University of Würzburg, Würzburg, Germany

[2] Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada

[3] Department of Management and Information Systems, Kent State University, Kent, OH 44242, USA

ABSTRACT

This paper studies a buying company which intends to improve the performance of one of its suppliers and considers alternative forms of supplier development. First, the buyer may assist the supplier in developing the know-how that is necessary to improve its production process, e.g., by helping to create an environment that facilitates learning. Second, the buyer may transfer knowledge which has been developed in the own company to the supplier, e.g., by training the employees of the supplier. Third, the buyer may pay for knowledge to be transferred to the supplier, e.g., by hiring a consulting firm. Assuming that all three alternatives lead to costs, the paper aims to identify an optimal mixture of supplier development activities to minimise the sum of supplier development and production costs.

INTRODUCTION

The supply base of a company, if appropriately managed, has been considered to be a potential source of sustainable competitive advantage (e.g. Dyer 1996; Krause et al. 1998). If a company believes that the performance or capabilities of its suppliers need to be improved, supplier development programs offer the opportunity to create a fit between suppliers' abilities and supply needs (Krause 1997; Wagner 2010). Reasons why companies engage in supplier development programs are manifold and include the underperformance of existing or the unavailability of qualified suppliers as well as the wish to extend the existing supplier base (Watts and Hahn 1993; Wagner 2006).

Research on supplier development has focused on the antecedents of supplier development, different supplier development activities, the process of supplier development or the impact of supplier development on the performance of the supplier. Kotabe et al. (2003), for example, studied the impact of relationship duration on the success of supplier development activities and found that especially in the case where higher-level technology is transferred from the buyer to the supplier, the duration of the buyer-supplier relationship, and possibly the trust that builds between them and the familiarity with each other's processes and operational methods that usually emerge in the course of it, is a critical success factor of a supplier development program. Further antecedents of successful supplier development include evaluation and certification efforts as well as efficient communication networks (Modi and Mabert 2007). Monczka et al. (1993), Krause (1997) and Wagner (2006), among others, conducted empirical studies which aimed on analysing methods buying firms use in developing their suppliers. Their results indicate that companies rely both on direct and indirect methods of supplier development and that setting performance goals for the supplier, conducting education and training programmes or providing advanced technology, support personnel, equipment or capital are among the most frequently used supplier development measures. Krause et al. (1998) proposed a process model and used it to investigate how different supplier development scenarios impact supplier performance. Krause and Ellram (1997) and Sako (2004) showed that a high degree of a buyer's involvement in supplier development through the direct contact between their employees may lead to a significant improvement of the suppliers. When combining supplier development activities, however, it has to be considered that not all possible measures are necessarily compatible. In this context, Wagner (2010) showed that indirect supplier development activities (such as supplier assessment or instilling competition among suppliers) may counteract direct supplier development activities (such as providing financial resources or transferring knowledge), wherefore it is advisable to concentrate on one of these categories.

A closer look at the literature reveals that prior research has predominantly been conceptual or empirical in nature. Models that mathematically relate supplier development activities to performance are scarce in the literature. Mathematical models are useful tools as they provide quantitative measures that help decision makers in understanding how one input affects the output (performance). One of the few mathematical models in this area, which we came across, is that of Talluri et al. (2010) who modelled supplier development as a financial investment problem under risk. Their objective is to minimise the variance of the supplier development investment portfolio. Talluri et al. (2010) studied two scenarios, one where a single buyer deals with multiple suppliers and decides the amount to invest into each supplier's process, and one with two buyers that jointly invest in their suppliers' processes.

This paper develops a mathematical model for supplier development and considers three alternatives that the buyer may adopt to improve the performance of its supplier. Specifically, we focus on the creation and the transfer of knowledge and assume that the buyer may influence knowledge build-up at the supplier. The transfer of knowledge, for example, can be attained by establishing information and communication systems, by providing training to the supplier’s employees or by exchanging personnel between the companies (see, e.g., Monczka et al. 1993; Krause 1997; Krause and Ellram 1997; Humphreys et al. 2004; Sako 2004; Talluri et al. 2010; Wagner 2006; Wagner 2010). However, when transferring knowledge between companies (and ultimately between individuals), it has to be considered that the absorption and implementation of knowledge follows specific rules and that knowledge is not available at once, but has to be built up over time (e.g. Nonaka 1994). As has been shown in prior research on learning processes, the build-up of knowledge at individuals may be described in the form of a power learning curve, where a lot of knowledge is accumulated at the beginning of the process and less knowledge is added as the process continues (or, in other words, performance increases at a decreasing marginal rate). For further reading on learning curves models, theory and applications see Jaber (2011).

The remainder of the paper is organised as follows. The next section develops a mathematical model which considers alternative forms of supplier development activities. Section 3 contains numerical examples, and Section 4 concludes the paper.

THE MODEL

Learning in production processes has frequently been studied in the past (see Jaber (2006) for a review of related literature). The focus of prior research was mainly on how learning occurs at either the individual or the organisation levels with less attention paid to the question of how a third-party can induce learning at any level. One exception is the paper of Ryu et al. (2005) who studied three interdependent learning processes, which they termed as learning-by-doing, learning-by-investment, and learning-from-others. The learning-by-doing process was assumed to conform to the Wright learning curve (1936), while learning-by-investment and learning-from-others were used to take account of the fact that knowledge may not only be developed internally, but also be transferred from a second party (for example a group member) or bought externally. In formulating their model, the authors used a Cobb-Douglas-function as it is more appropriate to describe a scenario where different types of knowledge, which are interdependent and mutually reinforcing, interplay. A model studying investment in learning processes can further be found in Dorroh et al. (1994), and a paper treating knowledge as a good that can be traded in internal markets is due to Ba et al. (2001).

In this paper, we assume that the buyer has three alternatives to influence the build-up of the supplier's knowledge and subsequently improve its performance. First, the buyer may invest in the learning process of the supplier to increase the rate at which the supplier improves on the learning curve. Second, the buyer may transfer knowledge to the supplier that has been acquired or is to be acquired in the course of the buyer-supplier relationship; one example is transferring workers from the buyer to the supplier for the purpose of training its workers. Third, the buyer may decide to purchase from an external source (e.g., hiring a consulting firm) the knowledge needed to enhance its supplier's performance. We follow Ryu et al. (2005) by assuming that the three types of knowledge reinforce each other and we adopt the Cobb-Douglas function to describe learning, which is of the form

(1) $L_t = \mu\big((\alpha + D)t\big)^{-l_D}(It)^{-l_I}(RH_t t)^{-l_T}$

The first component in (1), $\mu\big((\alpha + D)t\big)^{-l_D}$, represents learning-by-doing where μ is the time required to produce the first unit of output (without learning), α is an indicator of the supplier's initial position on the learning curve, D is the buyer's investment in the supplier's learning process (as an equivalent of experience units), t is the time count, and l_D as the learning parameter in learning-by-doing. The second component of (1), $(It)^{-l_I}$, represents learning-by-investment, with I as the capital the buyer invests in the supplier's process (translated to equivalent units of experience), and l_I is the learning parameter in learning-by-investment. The last component of (1), $(RH_t t)^{-l_T}$, finally represents the knowledge that the supplier receives from the buyer, where R is the effort spent on transferring knowledge (as an equivalent of experience units), H_t is the amount of knowledge available at the supplier at time t, and l_T is the learning parameter in knowledge transfer. H_t is given as

(2) $H_t = Ft^{l_b}$

with F as an indicator of the buyers initial position on the learning curve and l_b as the learning parameter of the buyer. It is clear that the three processes of knowledge creation considered in this paper are mutually interdependent, wherefore at least a small investment in the purchase of external knowledge or a knowledge transfer associated with either a positive level of initial knowledge or an investment in the learning process of the supplier is necessary to obtain a value of L_t that is smaller than a very large value (infinity). From a practical standpoint, this condition seems to be justified as it may be assumed that a supplier-buyer relationship is not successful unless the buyer shares a minimum amount of information with the supplier (for example the characteristics of the required product). If the supplier is not susceptible to the knowledge transferred directly or via a proxy by the buyer, or if the necessary skills and abilities needed to improve the supplier's product and process performance cannot be provided by the buyer because the buyer lacks them, or if the needed skills cannot be subcontracted to a third-party, then no improvement will occur.

The learning curve given in (1) consequently equals a product of three individual learning curves. Badiru (1992, 1995) describes these types of learning curves as multivariate learning curves and provides a review of common models and their applications. He notes that multivariate learning curves play an important role in manufacturing performance analysis, as they are able to describe the relationship between the learning environment and the outcomes of the learning process in greater detail than univariate models. In this paper, we follow the common assumption that the power expression $(\cdot)^{-l}$ in learning curves is unitless, wherefore (1) adopts the measurement units/time.

The time to produce Q units at the supplier may now be calculated by integrating the learning curve given in (1) over the limits 0 and Q (see Jaber and Bonney 1998), which leads to

(3) $$t_p(Q) = \int_0^Q \mu\big((\alpha + D)t\big)^{-l_D}(It)^{-l_I}(RH_t t)^{-l_T}\mathrm{d}t = \frac{\mu}{1-\gamma} Q^{1-\gamma}(\alpha + D)^{-l_D} I^{-l_I}(FR)^{-l_T}$$

with $\gamma = l_D + l_I + l_T + l_b l_T$.
The time weighted inventory for producing a lot of size Q can be derived by solving (3) for Q and by integrating the resulting expression over the limits 0 and t_p. Doing so gives

(4) $$TWI(Q) = \frac{\gamma-1}{\gamma-2}\left(\frac{(1-\gamma)(\alpha+D)^{l_D} I^{l_I}(FR)^{l_T}}{\mu}\right)^{\frac{1}{1-\gamma}}\left(\frac{\mu Q^{1-\gamma}(\alpha+D)^{-l_D} I^{-l_I}(FR)^{-l_T}}{1-\gamma}\right)^{\frac{2-\gamma}{1-\gamma}}$$

The production time for lot j with j = 1,..., J and J being the total number of lots in the planning period, may be calculated as

(5) $$t_{p,j} = t_p(jQ) - t_p\big((j-1)Q\big)$$

Inventory for lot j with j = 1,..., J is consequently given as

(6) $$TWI_j = TWI(jQ) - \sum_{k=2}^{j}(k-1)t_{p,k}Q - \sum_{k=1}^{j-1} TWI_k$$

The total cost function of the system, which we use as the objective function of the buyer, may now be formulated as follows

(7) $$TC = \sum_{j=1}^{J} TWI_j h^{(v)} + SJ + \frac{B^2 h^{(b)}}{2Jd} + KJ + c_I I + c_D D + c_R R$$

where $h^{(v)}$ is the inventory carrying costs of the supplier, S is the supplier's setup costs, B is the demand in the planning period, d is the demand rate of the buyer, $h^{(b)}$ is the buyer's inventory carrying cost, K is the buyer's order cost, and c_I, c_D and c_R are cost parameters the investment into the respective supplier development processes.

NUMERICAL EXAMPLES

To illustrate the behaviour of our model, we consider the following numerical example: B = 500, S = 250, K = 50, $h^{(v)}$ = 1, $h^{(b)}$ = 1.5, l_D = 0.05, l_I = 0.13, l_R = 0.1, l_b = 0.09, α = 10, F = 2, d = 100, μ = 100, c_I = 100, c_D = 50 and c_R = 65. Further, we assume that the demand B is satisfied in J equal lots of size $Q = B/J$. Learning-by-doing has the smallest learning rate in this example, while learning-by-investment has the highest learning rate. This could be justified as it is reasonable to assume that developing and acquiring new knowledge internally requires more time than transferring developed knowledge from external sources. Further, it can be seen that investing in internal learning processes is associated with a lower cost than investing in knowledge transfer or acquiring knowledge from an external source, i.e. c_D < c_R < c_I.

First, consider the case where the buyer only allocates minimum resources to developing the supplier processes, say D = I = R = 1. In this case, it is optimal to produce 89 lots, leading to total costs in the amount of 53783.92. If D, I and R are treated as decision variables, the buyer may decide to allocate more resources by increasing its invest in a supplier development program in hope that it will improve the supplier's performance. Higher values of D, I and R increase the production rate of the supplier, which reduces inventory carrying costs. For the present example, the optimal values for the supplier development variables are D = 8.34, I = 23.85 and R = 28.22, and further it is optimal to produce 60 lots. The total costs, in this case, amount to 41012.84 (cf. Tables 1 and 2). The results show that increasing investing in the learning processes of the supplier reduces the number of lots in the planning period, since a higher production rate reduces the impact of inventory carrying costs on the total costs of the system, which gives the buyer the opportunity to economise on setup and ordering costs.

Table 1: Sample data sets used for numerical experimentation

#	l_D	l_I	l_R	l_b	c_D	c_I	c_R
1	0.05	0.13	0.10	0.09	50	100	65
2	0.10	0.13	0.10	0.09	50	100	65
3	0.15	0.13	0.10	0.09	50	100	65
4	0.05	0.13	0.10	0.04	50	100	65
5	0.05	0.13	0.10	0.14	50	100	65
6	0.05	0.13	0.10	0.09	60	100	65
7	0.05	0.13	0.10	0.09	70	100	65
8	0.05	0.13	0.10	0.09	80	100	65

Later, we varied several of the model parameters to gain further insights into the behaviour of the model. Results of examples #2 and #3 shown in Tables 1 and 2 illustrate that an increase in the learning rate of one particular supplier development alternative makes it beneficial for the buyer to invest additional capital in this alternative. Simultaneously, the buyer invests less in the other two supplier development alternatives. Examples #1, #4 and #5 illustrate that as the learning rate of the buyer becomes faster, the investment in knowledge transfer is increased as transferring knowledge from the buyer to the supplier becomes more beneficial with an increasing amount of knowledge available at the buyer. Examples #6 to #8 finally show that an increase in one of the cost factors reduces the investment in this alternative, while the investment in the other alternatives is increased. The shift in investment preferences, however, cannot compensate the higher cost, wherefore the total cost increase as well.

Table 2: Results of the numerical study

#	*D*	*I*	*R*	*J*	*TC*
1	8.34	23.85	28.22	60	41012.84
2	20.21	19.64	23.24	49	34330.73
3	27.20	16.12	19.08	45	28659.90
4	8.46	24.00	28.40	49	41462.44
5	8.00	23.40	27.69	61	40567.61
6	5.20	23.71	28.06	60	41079.50
7	3.11	23.86	28.23	61	41120.52
8	1.53	23.98	28.38	61	41143.36

SUMMARY AND CONCLUSIONS

This paper studied alternative supplier development methods a buying company may implement to increase the performance of its supplier. First, the buyer may assist the supplier in facilitating the development of know-how in production, for example by helping to create an environment that facilitates learning. Second, the buyer may transfer knowledge which has been developed in-house to the supplier, for example by training the workers of the supplier. Third, the buyer may purchase knowledge from an external expert source and make it available at the supplier, for example by hiring a consulting firm. To the best of the authors' knowledge, this paper is the first to study these supplier development methods in a mathematical model. The results of the paper show that the performance of the supplier may be increased considerably if supplier development methods are applied, and that the total costs of the supply chain may be reduced significantly.

To extend the scope of this paper, future work could concentrate on studying supplier development as a bargaining problem. If the performance of the supplier depends on investment decisions of the supplier as well, it would be interesting to study negotiation processes between a buyer and a supplier and to analyse how the costs of process improvements are distributed between the supply chain partners. Further, in case the supplier delivers to other customers as well, it would be interesting to analyse external effects the investment of the buyer has on the total costs of other customers of the supplier. Especially, in case two of the supplier's customers are in direct competition, strategic considerations would have to be integrated into the model as well. Finally, considering stochastic components in supplier development would be interesting. In case the effect of investing in a supplier development program is uncertain, the behaviour of the buyer towards the supplier should be completely different as compared to the deterministic model presented in this paper.

ACKNOWLEDGEMENT
The first author wishes to thank the in-kind support provided to him, as a visiting researcher, by Ryerson University, Toronto, Canada, and the Natural Science and Engineering Research Council (NSERC) of Canada for their partial financial support. This work was further supported by a fellowship within the Postdoc-Programme of the German Academic Exchange Service (DAAD). The second author thanks NSERC for their financial support.

REFERENCES

Ba S J; Stallaert J; Whinston A B (2001) "Optimal Investment in Knowledge within a Firm Using a Market Mechanism", Management Science, 47 (9), 1203-1219.
Badiru A B (1992) "Computational Survey of Univariate and Multivariate Learning Curve Models", IEEE Transactions on Engineering Management, 39 (2), 176-188.
Badiru A B (1995) "Multivariate analysis of the effect of learning and forgetting on product quality", International Journal of Production Research, 33 (3), 777-794.
Dorroh J R; Gulledge T R; Womer N K (1994) "Investment in Knowledge: A Generalization of Learning by Experience", Management Science, 40 (8), 947-958.
Dyer J H (1996) "Specialized supplier networks as a source of competitive advantage: evidence from the auto industry", Strategic Management Journal, 17 (4), 271-291.
Humphreys P K, Li W L, Chan L Y (2004) "The impact of supplier development on buyer-supplier-performance", Omega, 32 (2), 131-143.
Jaber M Y (Ed.) (2011) "Learning Curves: Theory, Models, and Applications", CRC Press (Taylor and Francis Group), FL: Baco Raton
Jaber M Y (2006) "Learning and Forgetting Models and Their Applications", Badiru A B (Ed.), Handbook of Industrial and Systems Engineering, CRC/Taylor & Francis: Boca Raton, 30.1-30.27.
Jaber MY; Bonney M (1998) "The effects of learning and forgetting on the optimal lot size quantity of intermittent production runs", Production Planning & Control, 9 (1), 20-27.
Kotabe M; Martin X; Domoto H (2003) "Gaining from vertical partnerships: Knowledge transfer, relationship duration, and supplier performance improvement in the U.S. and Japanese automotive industries", Strategic Management Journal, 24 (4), 293-316.
Krause D R (1997) "Supplier Development: Current Practices and Outcomes", International Journal of Purchasing and Materials Management, 33 (2), 12-19.
Krause D R; Ellram L (1997) "Success factors in supplier development" International Journal of Physical Distribution & Logistics Management, 27 (1), 39-52.
Krause D R; Handfield R B; Scannell T V. (1998) "An empirical investigation of supplier development: reactive and strategic processes", Journal of Operations Management, 17 (1), 39-58.
Modi S B; Mabert V A (2007) "Supplier development: Improving supplier performance through knowledge transfer", Journal of Operations Management, 25 (1), 42-64.
Monczka R M; Trent R J; Callahan T J (1993) "Supply Base Strategies to Maximize Supplier Performance", International Journal of Physical Distribution & Logistics Management, 23 (4), 42-54.
Nonaka I (1994) "A Dynamic Theory of Organizational Knowledge Creation", Organization Science, 5 (1), 14-37.
Ryu C; Kim Y J; Chaudhuri A; Rao H R (2005) Knowledge Acquisition via Three Learning Processes in Enterprise Information Portals: Learning-by-Investment, Learning-by-Doing, and Learning-from-Others, MIS Quarterly, 29 (2), 245-278.
Sako M (2004) "Supplier development at Honda, Nissan and Toyota: Comparative case studies of organizational capability enhancement", Industrial and Corporate Change, 13 (2), 281-308.
Talluri S; Narasimhan R; Chung W (2010) "Manufacturer cooperation in supplier development under risk", European Journal of Operational Research, 207 (1), 165-173.

Wagner S M (2006) "Supplier development practices: an explorative study", European Journal of Marketing, 40 (5/6), 554-571.
Wagner S M (2010) "Indirect and Direct Supplier Development: Performance Implications and Combined Effects, IEEE Transactions on Engineering Management, 57 (4), 536-546.
Watts C A; Hahn C K (1993) "Supplier Development Programs: An Empirical Analysis", The Journal of Supply Chain Management, 29 (2), 11-17.
Wright T P (1936) "Factors affecting the cost of airplanes", Journal of the Aeronautical Science, 3 (4), 122-128.

A VENDOR–BUYER SUPPLY CHAIN WITH VARIABLE FRACTION OF DEFECTIVES

M Khan[1], M Y Jaber[1], C H Glock[2]
[1]Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada
[2]Chair of Business Management and Industrial Management, University of Würzburg, Würzburg, Germany

ABSTRACT
An analytical model for a two level supply chain will be developed with different approaches in the literature. Two approaches given by Urban (1998) and Hou (2007) will be used to model the fraction of defectives from the vendor. To our knowledge, this approach of treating the fraction of defectives as a variable in a supply chain context will be the first one. This research will further be enhanced to bring in more practical issues such as learning in the quality of vendor's items from cycle to cycle.

This piece of research provides practitioners with an important finding on how to perceive a supplier or vendor in terms of its quality in a long term contract. This would be of particular interest to industries where cost of quality plays a role.

Purpose
The purpose of this paper is to answer the research question that how the fraction of defectives shall impact a vendor-buyer supply chain if it is not a fixed value.

INTRODUCTION
The industry in today's competitive markets is constantly striving to improve its performance. The performance measures in this regard have been the overall running cost of the business, the share of benefit in a supply chain, customer satisfaction, and defective items returning from the market and the level of trust between stakeholders in a close-knit coordination. Though the response time has become very small due to the advancement in information technology, the industry has to do a lot to get to a zero-defect level. This issue is more significant where human workers are involved in a number of stages of product development.

Economic order quantity, EOQ (Harris, 1915) has been a corner stone for many researchers in the field of inventory and supply chain management for long. Though it has been widely accepted and exercised it has some dubious assumptions.

The literature pertaining to this stream of research includes models of both single-stage holder and multi-stage scenarios. Porteus (1986), Rosenbalatt and Lee (1986), and Urban (1998) modelled a single-stage scenario with defective items in a lot. Porteus (1986) had pointed out that quality (probability of defective items) impacts the economic order quantity. He assumed that a process can go out of control with a fixed probability thus producing defective items. He had also suggested investing in a process to improve quality. Rosenblatt and Lee (1986) assumed that the time after which a process goes out of control in a cycle takes an exponential distribution. Urban (1998), on the other hand, suggested that the probability of defectives in a production process depends on the cycle length. Salameh and Jaber (2000) presented a new course for this field of literature. They suggested screening defective items at the buyer's end right after receiving a lot. These defective items were sold at a discounted price after screening. This paper has been extended a number of times recently, for example by Eroglu and Ozdemir (2007), Wee *et al*. (2007), Maddah and Jaber (2008) and Khan *et al*. (2010*a*, 2010*b*). On the other hand, examples of models describing a multi-stage scenario with defective items are Huang (2002), Goyal *et al*. (2003), Ben-Daya *et al*. (2003), Ben-Daya and Rahim (2003) and Ouyang *et al*. (2006).

Recently, there has been a trend to make investments in the efforts to improve quality (Lee, 2008). The goal of these models is to investigate the return of an investment in terms of quality. Lee *et al*. (1997) determined the optimal investment to improve the variance of the quality characteristic and hence the fraction of defectives in a multistage manufacturing facility. Lee (2005) studied joint investment in inventory and preventive maintenance to improve product and service quality in a multi-stage manufacturing system. Hou (2007) discussed the relationship among cycle length, setup reduction and the improvement in process quality. He found out a tradeoff between the investments to (*a*) reduce setup time, and (*b*) improve process quality. Guiffrida and Jaber (2008) modelled a serial supply chain to reduce the delivery variance by using a logarithmic investment function. Uthayakumar and Parvathi (2009) presented a model to simultaneously minimize the lead time, yield variability and setup cost with the help of an investment.

In this paper, a vendor-buyer inventory model (Hill, 1997) will be presented that incorporates defective items from the vendor (Huang, 2002 and Khan *et al*., 2011). The fraction of defectives will be assumed to be that given in Urban (1998). Besides, an investment function similar to that in Hou (2007) and Uthayakumar and Parvathi (2009) will be used to improve the vendor's outgoing quality. The impact of the order size and the capital investment on the vendor's fraction of defectives will be studied. Section 2 of the paper describes the nomenclature used in the model while section 3 outlines the model. Section 4 presents the numerical analysis while the section 5 concludes the paper and sheds light on possible future work.

NOMENCLATURE

n	=	Number of shipments from the vendor to the buyer in a production cycle (a decision variable)
Q	=	Size of shipment from the vendor to the buyer (a decision variable)
T	=	Time between successive shipments (years)
d	=	Buyer's unit screening cost ($)
x	=	Buyer's screening rate (units/year)
γ	=	Percentage of defective items supplied by vendor
D	=	Demand for the vendor (units/year)
P	=	Vendor's production rate (units/year)
c	=	Vendor's production cost per unit time ($/year)
T_p	=	Vendor's production time in a cycle
T_d	=	Time in a cycle when the vendor is not producing (depletion period)
A_v	=	Vendor's fixed ordering or setup cost
A_b	=	Buyer's setup cost
h_v	=	Vendor's unit holding cost for the product
h_b	=	Buyer's unit holding cost for the product
α, β	=	Parameters of the fraction of defectives in Urban (1998)
u	=	Parameter of investment in Hou (2007)

THE MODEL

Consider a vendor-buyer relationship where the vendor supplies equal shipments of a single product to the buyer in a number of shipments in a cycle. These shipments from the vendor are believed to contain a fraction of defectives which is not fixed. The buyer carries out a screening process to separate the defective items. The total cost of the vendor in a cycle is the sum of setup, carrying and production costs:

$$C_v(Q,n) = A_v + \frac{h_v n Q^2}{2D}\left\{(n-1) - (n-2)\frac{D}{P}\right\} + \frac{ncQ}{P} \tag{1}$$

The total cost of the buyer in one vendor cycle is the sum of ordering, carrying and screening costs:

$$C_b(Q,n) = nA_b + nh_b\left\{\frac{Q(1-\gamma)T}{2} + \frac{\gamma Q^2}{x}\right\} + ndQ \tag{2}$$

So, the total cost of the two level (vendor-buyer) supply chain in a cycle is:

$$\begin{aligned} TC(Q,n) = A_v &+ \frac{h_v n Q^2}{2D}\left\{(n-1) - (n-2)\frac{D}{P}\right\} + \frac{ncQ}{P} + nA_b \\ &+ nh_b\left\{\frac{Q(1-\gamma)T}{2} + \frac{\gamma Q^2}{x}\right\} + ndQ \end{aligned} \tag{3}$$

The expected total cost of the supply chain per cycle would be:

$$\begin{aligned} TC(Q,n) = A_v &+ \frac{h_v n Q^2}{2D}\left\{(n-1) - (n-2)\frac{D}{P}\right\} + \frac{ncQ}{P} + nA_b + nh_b\left\{\frac{Q(1-\gamma)T}{2} + \frac{\gamma Q^2}{x}\right\} \\ &+ ndQ \end{aligned} \tag{4}$$

or

$$\begin{aligned} TC(Q,n) = A_v + nA_b &+ \frac{nQ^2}{2D}\left[h_v\left\{(n-1) - (n-2)\frac{D}{P}\right\} + \frac{2h_b D\gamma}{x}\right] + \frac{ncQ}{P} \\ &+ \frac{nh_b Q(1-\gamma)T}{2} + ndQ \end{aligned} \tag{5}$$

As we have

$T = \frac{(1-\gamma)Q}{D}$, using nT as the total cycle time, the annual cost would be

$$\begin{aligned} TCU(Q,n) = &\frac{D}{(1-\gamma)Q}\left\{\frac{A_v}{n} + A_b\right\} + \frac{dD}{(1-\gamma)} \\ &+ \frac{Q}{2(1-\gamma)}\left[h_v\left\{(n-1) - (n-2)\frac{D}{P}\right\} + \frac{2h_b D\gamma}{x}\right] + \frac{cD}{P(1-\gamma)} + \frac{h_b Q(1-\gamma)}{2} \end{aligned} \tag{6}$$

or

$$\begin{aligned} TCU(Q,n) = &\frac{D}{(1-\gamma)Q}\left\{\frac{A_v}{n} + A_b\right\} + \frac{D}{(1-\gamma)}\left(d + \frac{c}{P}\right) \\ &+ \frac{Q}{2}\left[\frac{h_v}{(1-\gamma)}\left\{(n-1) - (n-2)\frac{D}{P}\right\} + h_b\left\{(1-\gamma) + \frac{2D\gamma}{x(1-\gamma)}\right\}\right] \end{aligned} \tag{7}$$

This model is similar to the one discussed by Huang (2002) and Khan *et al*. (2011). This model will now be extended in two directions: (i) a variable fraction of defectives will be used, and (ii) an investment function will be introduced to reduce this fraction. To our knowledge, this would be the very first effort to present this practical form of quality (fraction of defectives) in a vendor-buyer supply chain. Now using the reciprocal relationship of the fraction of defectives γ and the production quantity Q, given by Urban (1998) as

$$\gamma = \alpha + \frac{\beta}{Q} \qquad \forall \;\; 0 \le \alpha \le 1 \tag{8}$$

The above annual cost becomes

$$TCU(Q,n) = \frac{D}{(1-\alpha)Q-\beta}\left\{\frac{A_v}{n}+A_b\right\} + \frac{D}{\left(1-\alpha-\frac{\beta}{Q}\right)}\left(d+\frac{c}{P}\right)$$
$$+\frac{Q}{2}\left[\frac{h_v}{\left(1-\alpha-\frac{\beta}{Q}\right)}\left\{(n-1)-(n-2)\frac{D}{P}\right\} + h_b\left\{\left(1-\alpha-\frac{\beta}{Q}\right)+\frac{2D\left(\alpha+\frac{\beta}{Q}\right)}{x\left(1-\alpha-\frac{\beta}{Q}\right)}\right\}\right] \tag{9}$$

An Excel macro will be used to find the optimal shipment size by fixing the number of shipments. An optimal number of shipments will be determined through iteration. To investigate the impact of the constant β in Eq. (8), a sensitivity analysis was carried out and results are shown in Figure 1.

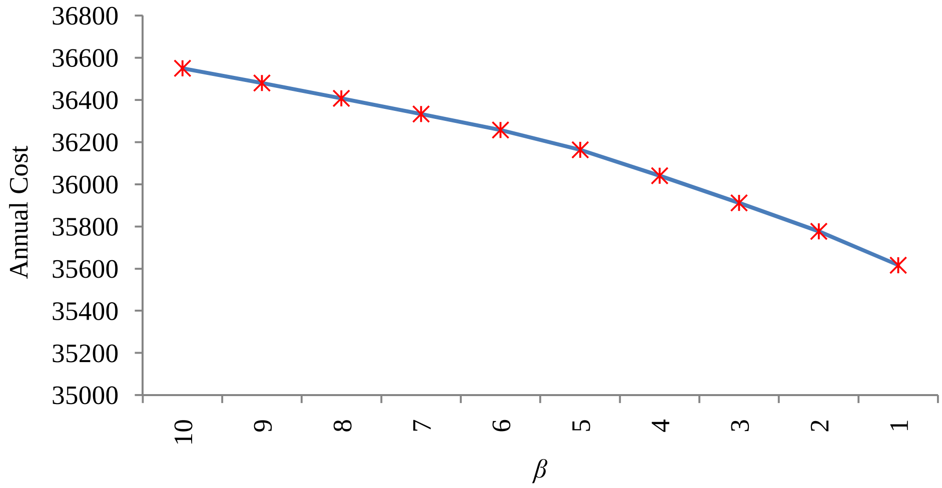


Figure 1. Annual Cost of the Supply Chain with *β*

Another suggestion that we make in this paper is to invest on an annual basis some amount to combat the vendor's fraction of defectives. A simple investment function (Hou, 2007 and Uthayakumar and Parvathi, 2009) will be used to impact the value of α in Eq. (8). The investment function is given by

$$\Phi(\alpha) = u\,ln\left(\frac{\alpha_0}{\alpha}\right) \tag{10}$$

where α_0 is the initial value of fraction of defectives (α) and $1/u$ is the fraction of reduction in α per dollar increase in $\Phi(\alpha)$. Assuming α is reduced to α':

$$\alpha' = \alpha_0 e^{\frac{\Phi(\alpha)+1}{u}}$$

or

$$\frac{1}{u} = \frac{\alpha-\alpha'}{\alpha} \tag{11}$$

So, the annual cost in Eq. (9) can be written as

$$TCU(Q,n) = \frac{D}{(1-\alpha)Q-\beta}\left\{\frac{A_v}{n}+A_b\right\}+\frac{D}{\left(1-\alpha-\frac{\beta}{Q}\right)}\left(d+\frac{c}{P}\right)$$
$$+\frac{Q}{2}\left[\frac{h_v}{\left(1-\alpha-\frac{\beta}{Q}\right)}\left\{(n-1)-(n-2)\frac{D}{P}\right\}+h_b\left\{\left(1-\alpha-\frac{\beta}{Q}\right)+\frac{2D\left(\alpha+\frac{\beta}{Q}\right)}{x\left(1-\alpha-\frac{\beta}{Q}\right)}\right\}\right]+u\,ln\left(\frac{\alpha_0}{\alpha}\right) \tag{12}$$

The impact of investment on the annual cost is shown in Figure 2 below:

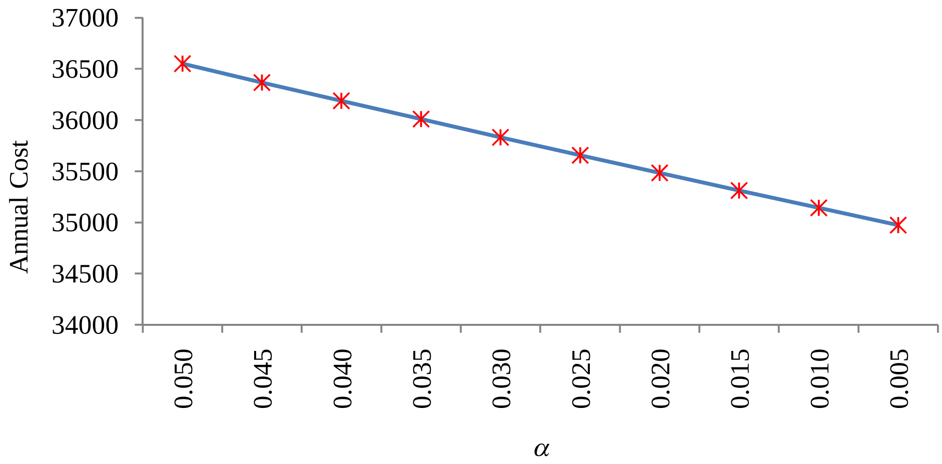


Figure 2. Annual Cost of the Supply Chain with α

It should be noticed that the annual cost improves with a little investment to limit the fraction of defectives. The above behaviour shows a promising future for the researchers in the field of inventory and supply chain management.

CONCLUSIONS

A new direction of research has been identified in this paper for two level vendor buyer supply chain. The probability of defective items has always been taken to be a known parameter which is usually dictated by the history of a machine or plant. This paper takes this fraction as a variable and introduces two methodologies to reduce it. It was noticed that a little investment can result in savings in the annual cost of the two level supply chain. It should be noticed that the two factors affecting the product quality, α and β, in Eq. (8) could be also be enhanced by investing in the transportation equipment and tools/machinery in a plant, respectively. This paper can also be extended to investigate the impact of inspection errors and the cost of warranty on different coordination schemes in a supply chain.

ACKNOWLEDGEMENTS

The authors would like to thank Natural Sciences and Engineering Research Council (NSERC) for funding this research.

REFERENCES

Ben-Daya, Darwish, M.A. and Rahim, A., (2003), Two-stage imperfect production systems with inspection errors", International Journal of Operations and Quantitative Management, Vol. 9, No. 2, pp. 117-131.

Ben-Daya, M. and Rahim, A., (2003), "Optimal lot-sizing, quality improvement and inspection errors for multistage production systems", International Journal of Production Research, Vol. 41, No. 1, pp. 65-79.

Eroglu, A. and Ozdemir, G., (2007), "An economic order quantity model with defective items and shortages". International Journal of Production Economics, Vol. 106, No. 2, pp. 544-549.

Goyal, S.K., Huang, C.K. and Chen, K.C., (2003), "A simple integrated production policy of an imperfect item for vendor and buyer", Production Planning and Control, Vol. 14, No. 7, pp. 596-602.

Guiffrida, A.L. and Jaber, M.Y., (2008), "Managerial and economic impacts of reducing delivery

variance in the supply chain", Applied Mathematical Modeling, Vol. 32, No. 10, pp. 2149-2161.

Harris, F., (1915), "Operations and costs", Factory Management Series, pp. 48–52, Shaw, Chicago.

Hill, R.M., (1997), "The single-vendor single-buyer integrated production-inventory model with a generalized policy", European Journal of Operational Research, Vol. 97, No. 3, pp. 493-499.

Hou, K.L., (2007). "An EPQ model with setup cost and process quality as functions of capital expenditure", Applied Mathematical Modeling, Vol. 31, No. 1, pp. 10-17.

Huang, C.K., (2002), "An integrated vendor-buyer cooperative inventory model for items with imperfect quality", Production Planning and Control, Vol. 13, No. 4, pp. 355-361.

Khan, M., Jaber, M.Y. and Wahab, W.I.M., (2010a),"Economic order quantity model for items with imperfect quality with learning in inspection". International Journal of Production Economics, Vol. 124, No. 1, pp. 87-96.

Khan, M., Jaber, M.Y. and Bonney, M., (2010b),"An economic order quantity (EOQ) for items with imperfect quality and inspection errors", International Journal of Production Economics, doi:10.1016/j.ijpe.2010.01.023.

Khan, M., Jaber, M.Y. and Ahmad, A. R. (2011), "A vendor-retailer supply chain with errors in quality inspections and learning in production", Working Paper.

Lee, H.H., Chandra, M.J. and Deleveaux, V.J., (1997). Optimal batch size and investment in multistage production systems with scrap, Production Planning and Control, Vol. 8, No. 6, pp. 586-596.

Lee, H.H., (2005), "A cost/benefit model for investments in inventory and preventive-maintenance in an imperfect production system", Computers & Industrial Engineering, Vol. 48, No. 1, pp. 55-68.

Lee, H.H., (2008), "The investment model in preventive maintenance in multi-level production systems", International Journal of Production Economics, Vol. 112, No. 2, pp. 816-828.

Maddah, B. and Jaber, M.Y., (2008), "Economic order quantity for items with imperfect quality: Revisited". International Journal of Production Economics, Vol. 112, No. 2, pp. 808-815.

Ouyang, L.Y., Wu, K. and Ho, C.H., (2006),"Analysis of optimal vendor-buyer integrated inventory policy involving defective items", International Journal of Advanced Manufacturing Technology, Vol. 29, No. 11-12, pp. 1232-1245.

Porteus, E.L., (1986), "Optimal lot sizing, process quality improvement and setup cost reduction", Operations Research, Vol. 34, No. 1, pp. 137-144.

Rosenblatt, M.J. and Lee, H.L., (1986), "Economic production cycles with imperfect production processes", IIE Transactions, Vol. 18, No. 1, pp. 48-55.

Salameh, M.K. and Jaber, M.Y., (2000), "Economic production quantity model for items with imperfect quality", International Journal of Production Economics, Vol. 64, No. 1, pp. 59-64.

Urban, T.L., (1998), "Analysis of production systems when run length influences product quality", International Journal of Production Research, Vol. 36, No. 11, pp. 3085-3094.

Uthayakumar, R. and Parvathi, P. (2009), "A continuous review inventory model with controllable backorder rate and investments", International Journal of Systems Science, Vol. 40, No. 3, pp. 245-254.

Wee, H.M., Yu, J. and Chen, M.C., (2007), "Optimal inventory model for items with imperfect quality and shortage backordering", Omega, Vol. 35, No. 1, pp. 7-11.

THE IMPACT OF COMPLEMENTARY CAPABILITIES ON THE SUCCESS OF LOGISTICS OUTSOURCING IN AUSTRALIA

Violet Lazarevic
Monash University, Australia

INTRODUCTION

Globalisation has intensified competition resulting in the growth of outsourcing as a way to enhance efficiency (Hätönen and Eriksson, 2009). In particular, logistics activities are often outsourced to increase speed to market and improve competitive positioning (Lai, 2004). Literature suggests that in highly competitive environments it is unlikely that an organisation can possess all the capabilities needed to compete effectively (Narasimhan *et al.,* 2010). Organisations are increasingly realising their lack of internal logistics capabilities (Davis *et al.,* 2008). Consequently, they are outsourcing to 3PLs that have the skills needed to create superior market offerings (Espino-Rodriguez and Rodriguez-Diaz, 2008). Outsourcing has created highly specialised organisations that rely on leveraging supply chain partner's complementary capabilities to gain a competitive edge (Merino and Rodríguez, 2007).

For capabilities to be considered complementary they need to match by one party fulfilling what the other party lacks, or is not very good at (Sarkar *et al.,* 2001). A number of researchers suggest that complementary capabilities are crucial in outsourcing relationships (Arroyo *et al.,* 2006, Pagano, 2009). Complementarity is desirable as adding complementary capabilities increases the value of the capabilities the outsourcing organisation already possesses (Ennen and Richter, 2010). Thus, blending of specialised capabilities between the outsourcing organisation and the 3PL can create advantageous synergies, and competitive advantage (Rothaermel, 2001).

Complementarity has also been identified as having a positive effect on the outcome of inter-organisational partnerships (Zineldin and Bredenlow, 2003); however this relationship has not been supported by empirical research (Chung *et al.,* 2000; Pangarkar and Choo, 2001). Furthermore, the role of complementarity of capabilities in outsourcing arrangements has not been adequately addressed in previous research (Harrison *et al.,* 2001).

This paper aims to fill the gaps in existing research by examining the importance of complementary capabilities in logistics outsourcing. In addition, this paper seeks to determine whether complementary capabilities are necessary for obtaining superior customer service within outsourcing arrangements.

LITERATURE REVIEW

The make or buy decision leading to outsourcing is traditionally explained in the literature through transaction cost theory (Madhok, 2002; Jahns *et al.,* 2006). This theory states that organisational functions should be sourced from the market (outsourced) when the transaction costs are lower than undertaking that activity within the organisation (in-house) (Williamson, 1985). Transaction cost theory explains that logistics activities are often outsourced due to the high set up costs required in developing internal logistics capabilities (Ellram *et al.,* 2008).

Transaction cost theory also draws attention to the risk of uncertainty involved when activities are outsourced. This includes the ambiguity around performance of the activity and fulfilment of the contract (Williamson, 1975). This is particularly pertinent when the execution of the contract and the performance is difficult to assess. The theory predicts that when the buying firm has difficulty gauging the supplier's performance suppliers will act opportunistically (Williamson, 1975). Opportunism is defined as "self-seeking interest with guile" (Williamson, 1985 p.6). When this occurs the buying organisation may pay for something it does not receive (Ellram *et al.,* 2008). This would eliminate cost savings arising from sourcing the activity from the market rather than within the organisation.

However, the theory of transaction costs does have some limitations. For example the theory does not clarify when outsourcing partners may not act opportunistically (Leiblein and Miller, 2003) or how opportunism can be avoided. Further, the theory does not explain whether both parties need to understand the outsourced task (Ryu, 2006) in order for it to be completed successfully.

Outsourcing of logistics activities is generally considered less costly than undertaking these activities in-house (Cho *et al.,* 2008). As logistics activities have become more sophisticated, developing logistics expertise in-house has become more time consuming and expensive (Razzaque & Shang, 1998). As a result, many organisations do not possess the required capabilities to carry out their own logistics functions (Wong *et al.,* 2000). Instead they look for 3PL partners with complementary capabilities and expertise that they can rely on (Boyson *et al.,* 1999).

A number of researchers have emphasised the need for complementary capabilities in outsourcing partners (Doving and Gooderham, 2008; Hitt *et al.,* 2004). Complementary capabilities are considered important in both alliances and cooperative arrangements (Rabino *et al.,* 2008). Consequently, outsourcing organisations often seek a partner with resources and capabilities that the outsourcing organisation does not already own (Gulati *et al.,* 2000). Complementary capabilities work collaboratively with the capabilities the outsourcing organisation already possesses (Song *et al.,* 2005). This is distinct from supplementary or substitution capabilities that perform in the same way as capabilities that the outsourcing organisation already has (Parmigiani and Mitchell, 2009).

Complementary capabilities are defined as capabilities that "...are not identical, yet they simultaneously 'complement' each other" (Harrison *et al.,* 2001 p.680). This means that though they are not similar (Lin *et al.,* 2009), they do support each other (Ennen and Richter, 2010). When two organisations have complementary capabilities they have different and reciprocal strengths (Sarkar *et al.,* 2001). These different strengths are believed to help the outsourcing organisation to decrease any organisational weaknesses (Chung *et al.,* 2000); achieving a better competitive position together than one organisation can on its own (Matanda and Freeman, 2009). In addition, outsourcing relationships with complementary partners have been reported to improve outsourcing performance and success (Harrison *et al.,* 2001, Sarkar *et al.,* 2001).

Existing literature suggests that 3PLs are seen as representatives of the outsourcing organisation to the end customer (Morgan *et al.,* 2007). This means that their behaviour and performance can influence perceptions of customer service (Berry, 2000) and subsequent customer satisfaction (Lieb and Bentz, 2005). If the 3PL delivers inadequate customer service to the end customer it could negatively influence the performance of the outsourcing organisation (Maloni and Carter, 2006) and reduce the success of the outsourcing partnership.

METHODOLOGY

Given the limited existing research on the importance of complementary capabilities on outsourcing success an exploratory research design seemed appropriate (Geiger and Turley, 2005). Qualitative methodology enables researchers to gain valuable insights into business relationships, to better understand the research phenomena (Aaker *et al.,* 2005) and facilitate theory development (Eisenhardt and Graebner, 2007). The central premise of qualitative research is that multiple perspectives allow a better understanding of the research phenomena (Strauss and Corbin, 1994). Thus, the research design facilitates exploration of the views of outsourcing organisations as well as 3PLs to capture differences and similarities in perceptions of outsourcing partners (Homburg *et al.,* 2002).

As recommended by Morrow *et al.* (2005), in-depth interviews were carried out with 15 top supply chain and logistics managers that are critically placed to provide the most information-rich data possible on outsourcing relationships in Australia. Face-to-face or telephone interviews lasting 45 to 95 minutes were conducted. All interviews were tape-recorded and transcribed verbatim. A semi-structured interview guide was developed on the basis of the literature review and adapted as new concepts came to light during the interview process (Strauss and Corbin, 1998). A semi-structured format ensured all respondents were asked the same questions as well as allowing the exploration of emerging constructs (Aaker *et al.,* 2005). Data was collected until the point of theoretical saturation where no new concepts emerged (Strauss and Corbin, 1998).

The data was analysed using thematic analysis (Roulston, 2001). Thematic analysis allowed patterns and themes of similarity and differences within the data to be recognised and examined (Floersch *et al.,* 2010). A theme is defined as 'patterned response or meaning within the dataset' (Braun and Clarke, 2006 p. 82). These patterns were identified by a comparison of the themes within the data with prior knowledge of the research phenomena (Reissman, 2008). During the analysis the researcher looked for significant themes consistent across the data set (Patton, 2002). The findings were then categorized to permit comparison and facilitate the development of theoretical concepts (Strauss and Corbin, 1998).

FINDINGS

The research findings suggest a number of inconsistencies in perceptions of complementary capabilities in the industry. This section is split into two subsections outlining the major findings. Firstly, the lack of understanding of what complementary capabilities are is examined. Then, the opposing views regarding the importance of complementary capabilities are discussed followed by an exploration of the significance of a mutual understanding between outsourcing partners.

Understanding of complementarity

40 percents of respondents interviewed did not understand what complementarity was or how to assess whether capabilities were complementary to their own. Complementarity was sometimes confused with similarity, as respondent 1 stated *"no they don't have to be the same".* At other times it was confused with similar goals, *"we've all got to have the same goals"* (Respondent 10). Other confused respondents directly asked what the word meant *"What do you mean by that?"* (Respondent 2).

All respondents who did not understand complementary capabilities were offered the same definition used in this paper to facilitate further discussion.

Are complementary capabilities important?

The respondents in this study were divided in their perceptions of the importance of complementary capabilities. One third of respondents thought that complementarity is important for various reasons including that there was no need for the outsourcing organisation to know about logistics in order to concentrate on their own key competences, as respondent 5 indicated

"they mightn't know anything about logistics, and they don't need to know that, all they need to know is what they do best, the same with us".

Additionally, Respondents 6 and 8 pointed to the waste of having double investment if capabilities were not complementary. As illustrated by respondent 8 *"So if items are complementary and you can increase productivity then everybody wins... you wouldn't want duplication would you".*

Respondent 11 suggested that having complementary capabilities allowed both parties to invest more heavily in their mutual expertise, *"you tend to operate in niche areas that you are good at and therefore, you develop the skills required in those areas"*. In addition, having complementary capabilities meant that the 3PL was offering something unique and valuable to the outsourcing organisation, *"they need to have something unique to offer us"* Respondent 12.

Contrary to these views nearly half of the respondents suggested that complementary capabilities were not important in outsourcing relationships. Respondent 1 indicated that complementarity was not important as logistics was an independent activity compared to the activities carried out by outsourcing organisations. Respondent 7 highlighted the risk that if capabilities were complementary rather than overlapping, *"over time you would*

lose the skill set to run the distribution network". This would mean that the outsourcing organisation could not re-internalise the outsourced activity in the future due to skill loss and may also be unable to carry out tasks related to the outsourced activity in the supply chain. A major concern regarding complementary capabilities was the exposure to risk of opportunistic behaviour from the 3PL. Respondent 15 advised that *"you need to maintain expertise within your business that relates to the outsourced activities... so that you can retain management of it".*
Respondent 3 explained the motivation for opportunism *"they're not doing it in your interest, they're doing it as a commercial proposition and they'll do it like everybody does... the cheapest way possible and to the greatest benefit to themselves"* and this can be triggered when *"the 3PL knows that they* [the outsourcing organisation] *don't have the expertise, then they have a far wider scope to basically relax and do things that are in their interest rather than in the interest of their customer".*
Respondent 7 also cautions *"you don't want to be in a position where your 3PL has the capability or the knowledge and you don't"* because *"you need to understand the effectiveness of their operation".* Similarly, respondent 4 emphasised that if outsourcing organisations rely solely on the knowledge of their 3PL they may not get resolutions to problems that are in their best interests. Likewise, respondent 10 stated that overlapping capabilities facilitated the assessment of the performance and efficiency of the 3PL. This allowed the outsourcing organisation to determine whether the 3PL was performing as well as they could be.

The remaining four respondents believed that the importance of complementary capabilities would depend on the situation. For example, it would depend on who owned and operated the assets in the outsourcing arrangement according to Respondents 2 and 13. Respondent 9 felt that complementarity became more important as more logistics activities were outsourced. However, when only one activity was being outsourced and the rest were carried out in-house then overlapping capabilities were necessary to ensure a seamless operation. Respondent 14 proposed that the size of the outsourcing organisation would affect the importance of complementarity with outsourcing partners. If the organisation was large it would not need complementary capabilities from outsourcing partners as it had the capital to run dual sets of assets and operations. However, smaller organisations do not have the necessary funds and would therefore, consider complementary outsourcing partners more important.

More critical than complementary capabilities with little overlap of knowledge and expertise was a mutual understanding of *"each other's business"* (Respondent 1 and Respondent 9). When outsourcing partners understand each other's business and the resulting requirements they are more likely to work together more effectively according to Respondents 4, 5 and 7. Respondents 8, 10 and 13 stated that understanding between outsourcing partners allowed a seamless operation and functioning as one supply chain. The following extracts indicate that this understanding facilitates the working together between outsourcing partners and increases the success of the outsourcing partnership.
"It needs to be understood across the board by both parties exactly what's happening" – Respondent 12
"We need to understand what our clients are trying to do and understand the industry that they're in" – Respondent 6
This ability to understand each other was seen by two thirds of respondents as more important to outsourcing success than having a partner with complementary capabilities. In addition, when outsourcing partners understood each other the 3PL was more likely to deliver better customer service to the both the outsourcing organisation and the end customer.

DISCUSSION
This study contributes to the literature by challenging some previously held notions about complementary capabilities and their importance in outsourcing relationships. Two key findings that contest existing research concern the understanding of complementarity and the perception of its importance for outsourcing partnerships.

The findings suggest that complementarity is not well understood by logistics managers. This indicates that managers looking to outsource logistics may not know how to assess whether a potential partner has complementary capabilities. In addition, since some of the respondents who did not understand complementarity were from outsourcing organisations this finding contradicts previous literature which states that outsourcing organisations deliberately choose partners with complementary capabilities (Boyson *et al.,* 1999; Merino and Rodríguez, 2007; Matanda and Freeman, 2009).

This study indicates that many logistics managers do not consider complementary capabilities vital because of the resulting risk of opportunism when no overlapping capabilities exist. The danger of opportunism when complementary partners are relied on is consistent with predictions of transaction cost theory (Williamson, 1985; Ellram *et al.,* 2008). This occurs as a result of conflicting needs existing between the 3PL and the outsourcing organisation (Keep and Schneider, 2010). Consequently, when the outsourcing organisation does not have the capability or expertise to assess the 3PLs performance the 3PL may act opportunistically to serve their own purposes. This finding challenges existing literature which contends that outsourcing arrangements with complementary capabilities are more successful than arrangements where overlapping capabilities exist (Sarkar *et al.,* 2001; Holcomb and Hitt, 2007; Harrison *et al.,* 1991). The findings of this study advocate overlapping capabilities to enable outsourcing organisations to effectively manage 3PLs and eliminate the possibility of opportunism.

Opportunistic behaviour on the part of the 3PL may have a significant detrimental impact on the perceptions of customer service from the end customer on the receiving end of the 3PLs' services. This is due to customers perceiving 3PLs as representatives of the outsourcing organisation (Morgan *et al.,* 2007). Therefore, if the 3PL behaves opportunistically and lowers its performance it may affect availability of the product to the end customer which also negatively impacts on customer service. The results obtained here indicate that to achieve a successful outsourcing relationship the two parties need to understand each other's business and work together to provide a good level of customer service to the end customer.

Managerial Implications

The findings of this study have two important implications for outsourcing managers. The first is that outsourcing managers need to make sure that they have a good understanding of complementarity and what complementary capabilities are necessary in a potential outsourcing partner. Secondly, these results caution against mutually exclusive capabilities with outsourcing partners that allow no overlap of capability. This study shows that no overlap of capability between outsourcing partners carries risk of opportunistic behaviour from the 3PL. This indicates to outsourcing managers that retaining some knowledge regarding the outsourced task is necessary to ensure that the task is being carried out correctly by the 3PL. Additionally, a mutual understanding of each other's business was found to be more important for a successful outsourcing relationship able to deliver the required customer service to the end customer. This suggests that instead of relying on complementary partners outsourcing managers should ensure that their outsourcing partners understand their business and requirements for customer service.

CONCLUSION

This paper contributes to existing literature by pointing out the dangers of over-reliance on complementary outsourcing partners. Previous research claiming that overlap of capabilities between outsourcing partners was unnecessary and counter-productive has been refuted by these findings. Overlap of capabilities has been found to be necessary for minimising the risk of opportunistic behaviour and assessing the performance of 3PLs. In addition, this study indicates that a shared understanding between partners is more important than complementary capabilities in allowing them to work together and achieve better customer service for the end customer.

As a result of the exploratory nature of this research and a limited number of respondents it is difficult to generalise from the findings of this study. However, as well as providing a meaningful first step into research examining the importance of complementary capabilities within logistics outsourcing arrangements, this study also gives insight into how outsourcing organisations can minimise risk of opportunistic behaviour from the 3PL. This study also suggests that more research is needed to determine the magnitude and direction of the relationship between complementary capabilities and opportunistic behaviour, and how this affects the outsourcing partnership. In addition, future research could also investigate whether this finding is replicated in countries other than Australia.

REFERENCES

Aaker, D.A., Kumar, V., Day, G.S. & Lawley, M. (2005) *Marketing Research,* Milton, John Wiley & Sons Australia.

Arroyo, P., Gaytan, J. & De Boer, L. (2006) A survey of third party logistics in Mexico and a comparison with reports on Europe and USA. *International Journal of Operations & Production Management,* 26**,** 639-667.

Berry, L.L. (2000) Cultivating service brand equity. *Journal of the Academy of Marketing Science,* 28**,** 128-137.

Boyson, S., Corsi, T., Dresner, M. & Rabinovich, E. (1999) Managing effective third party logistics relationships: what does it take? *Journal of Business Logistics,* 20**,** 73-100.

Braun, V. & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.

Cho, J.J.-K., Ozment, J. & Sink, H. (2008) Logistics capability, logistics outsourcing and firm performance in an e-commerce market. *International Journal of Physical Distribution & Logistics Management,* 38**,** 336-359.

Chung, S.A., Singh, H. & Lee, K. (2000) Complementarity, status similarity and social capital as drivers of alliance formation. *Strategic Management Journal,* 21**,** 1-22.

Davis, D.F., Golicic, S.L. & Marquardt, A.J. (2008) Branding a B2B service: does a brand differentiate a logistics service provider? *Industrial Marketing Management,* 37**,** 218-227.

Doving, E. & Gooderham, P.N. (2008) Dynamic capabilities as antecedents of the scope of related diversification: the case of small firm accountacy practices. *Strategic Management Journal,* 29**,** 841-857.

Eisenhardt, K.M. & Graebner, M. E. (2007) Theory building from cases: opportunities and challenges. *Academy of Management Journal,* 50**,** 25-32.

Ellram, L.M., Tate, W.L. & Billington, C. (2008) Offshore outsourcing of professional services: a transaction cost economics perspective. *Journal of Operations Management,* 26**,** 148-163.

Ennen, E. & Richter, A. (2010) The whole is more than the sum of its parts- or is it? A review of the empirical literature on complementarities in organizations. *Journal of Management,* 36**,** 207-233.

Espino-Rodriguez T. F. & Rodriguez-Diaz, M. (2008) Effects of internal and relational capabilities on outsourcing: an integrated model. *Industrial Management & Data Systems,* 108**,** 328-345.

Floersch, J., Longhofer, J.L., Kranke, D. & Townsend, L. (2010) Integrating thematic, grounded theory and narrative analysis. *Qualitative Social Work,* 9**,** 407-425.

Geiger, S. & Turley, D. (2005) Socializing behaviors in business-to-business selling: an exploratory study from the Republic of Ireland. *Industrial Marketing Management,* 34**,** 263-273.
Gulati, R., Nohria, N. & Zaheer, A. (2000) Strategic networks. *Strategic Management Journal,* 21**,** 203-215.
Harrison, J.S., Hitt, M.A., Hoskisson, R.E. & Ireland, R.D. (1991) Synergies and post-acquisition performance: differences versus similarities in resource allocations. *Journal of Management,* 17**,** 173-190.
Harrison, J.S., Hitt, M.A., Hoskisson, R.E. & Ireland, R.D. (2001) Resource complementarity in business combinations: extending the logic to organizational alliances. *Journal of Management,* 27**,** 679-690.
Hatonen, J. & Eriksson, T. (2009) 30+ years of research and practice of outsourcing - exploring the past and anticipating the future. *Journal of International Management,* 15**,** 142-155.
Hitt, M.A., Ahlstrom, D., Dacin, M.T., Levitas, E. & Svobodina, L. (2004) The institutional effects on strategic alliance partner selection in transition economies: China vs. Russia. *Organization Science,* 15**,** 173-185.
Holcomb, T.R. & Hitt, M.A. (2007) Toward a model of strategic outsourcing. *Journal of Operations Management,* 25**,** 464-481.
Homburg, C., Schneider, J. & Fassnacht, M. (2002) Opposites attract, but similarity works: a study of interorganizational similarity in marketing channels. *Journal of Business to Business Marketing,* 10**,** 31 - 54.
Jahns, C., Hartmann, E. & Bals, L. (2006) Offshoring: dimensions and diffusion of a new business concept. *Journal of Purchasing and Supply Management,* 12**,** 218-231.
Keep, W.W. & Schneider, G.P. (2010) Deception and defection from ethical norms in market relationships: a general analytic framework. *Business Ethics: A European Review,* 19**,** 64-80.
Lai, K.-H. (2004) Service capability and performance of logistics service providers. *Transportation Research Part E: Logistics and Transportation Review,* 40**,** 385-399.
Leiblein, M.J. & Miller, D.J. (2003) An empirical examination of transaction-and firm-level influences on the vertical boundaries of the firm. *Strategic Management Journal,* 24**,** 839-858.
Lieb, R. & Bentz, B.A. (2005) The use of third-party logistics services by large American manufacturers: the 2004 survey. *Transportation Journal,* 44**,** 5-15.
Lin, Z.J., Yang, H. & Arya, B. (2009) Alliance partners and firm performance: resource complementarity and status association. *Strategic Management Journal,* 30**,** 921-940.
Madhok, A. (2002) Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal,* 23**,** 535-550.
Maloni, M. & Carter, C. R. (2006) Opportunities for research in third-party logistics. *Transportation Journal,* 45**,** 23-38.
Marshall, D., McIvor, R. & Lamming, R. (2007) Influences and outcomes of outsourcing: insights from the telecommunications industry. *Journal of Purchasing and Supply Management,* 13**,** 245-260.
Matanda, M.J. & Freeman, S. (2009) Effect of perceived environmental uncertainty on exporter-importer inter-organisational relationships and export performance improvement. *International Business Review,* 18**,** 89-107.
Merino, F. & Rodriguez, D. (2007) Business services outsourcing by manufacturing firms. *Industrial and Corporate Change,* 16**,** 1147-1173.
Morgan, F., Deeter-Schmelz, D. & Moberg, C.R. (2007) Branding implications of partner firm-focal firm relationships in business-to-business service networks. *Journal of Business & Industrial Marketing,* 22**,** 372 - 382.
Morrow, J.L., Sirmon, D.G., Hitt, M.A. & Holcomb, T.R. (2005) Creating value in the face of declining performance: designing actions to effect organizational recovery. *Strategic Management Society.* Orlando, Florida.

Narasimhan, R., Narayanan, S. & Srinivasan, R. (2010) Explicating the mediating role of integrative supply management practices in strategic outsourcing: a case study analysis. *International Journal of Production Research,* 48**,** 379-404.

Pagano, A. (2009) The role of relational capabilities in the organization of international sourcing activities: A literature review. *Industrial Marketing Management,* 38**,** 903-913.

Pangarkar, N. & Choo, A. (2001) Do firms seek symmetric alliance partners? An exploratory study. *Journal of Asia-Pacific Business,* 3**,** 83 - 100.

Parmigiani, A. & Mitchell, W. (2009) Complementarity, capabilities and the boundaries of the firm: the impact of within-firm and interfirm expertise on concurrent sourcing of complementary components. *Strategic Management Journal,* 30**,** 1065-1091.

Patton, M. Q. (2002) *Qualitative Research and Evaluation Methods,* Thousand Oaks, Sage.

Rabino, S., Simoni, C. & Zanni, L. (2008) Small & medium gold & fashion enterprises (SMEs) in Arezzo, Italy: competitive challenges and strategic implications. *Journal of Global Marketing,* 21**,** 141 - 159.

Reissman, C.K. (2008) *Narrative Methods for the Human Sciences,* Thousand Oaks, Sage Publications.

Rothaermel, F.T. (2001) Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal,* 22**,** 687-699.

Roulston, K. (2001) Data analysis and 'theorizing as ideology'. *Qualitative Research,* 1**,** 279-302.

Ryu, S. (2006) The effect of external and internal environments on interfirm governance. *Journal of Business to Business Marketing,* 13**,** 67-90.

Sarkar, M.B., Echambadi, R., Cavusgil, S.T. & Aulakh, P.S. (2001) The influence of complementarity, compatibility, and relationship capital on alliance performance. *Journal of the Academy of Marketing Science,* 29**,** 358-373.

Song, M., Droge, C., Hanvanich, S. & Calantone, R. (2005) Marketing and technology resource complementarity: an analysis of their interaction effect in two environmental contexts. *Strategic Management Journal,* 26**,** 259 - 276.

Strauss, A. & Corbin, J. (1994) Grounded theory methodology: an overview. In Denzin, N. K. & Lincoln, Y. S. (Eds.) *Handbook of qualitative research.* London, Sage Publications.

Strauss, A. & Corbin, J. (1998) *Basics of qualitative research,* Thousand Oaks, Sage.

Williamson, O.E. (1975) *Markets and hierarchies: analysis and antitrust implications: a study in the economics of internal organization,* New York, Free Press.

Williamson, O.E. (1985) *The economic institutions of capitalism,* New York, The Free Press.

Wong, Y.-Y., Maher, T. E., Nicholson, J. D. & Gurney, N. P. (2000) Strategic alliances in logistics outsourcing. *Asia Pacific Journal of Marketing and Logistics,* 12**,** 3-21.

Zineldin, M. & Bredenlow, T. (2003) Strategic alliance: synergies and challenges: a case of strategic outsourcing relationship "SOUR". *International Journal of Physical Distribution & Logistics Management,* 33**,** 449-464.

MANAGING SUPPLIER RELATIONSHIP: CASE STUDIES OF SMALL AND MEDIUM ASIAN GROCERY RETAILERS IN AUSTRALIA

Thi Viet Hoa Tran, Booi H. Kam
RMIT University, Melbourne, Australia
Chandra S. Lalwani
Business School, University of Hull, UK

1. INTRODUCTION

Extant literature on asymmetry in supplier-buyer relationships have tended to concentrate on the larger, stronger buyers (Johnsen and Ford, 2008) and how they capitalize on their buying power to exploit the asymmetrical relationships (e.g., Dobson and Chakraborty, 2008; Harrison, 2004; Mills, 2003). Relatively few studies have examined the manner in which the smaller party, be it supplier or buyer, copes with such an asymmetry. Given that asymmetry exists in supplier-buyer relationships, despite the opportunistic behaviour of the more powerful buyers, smaller buyers, expectedly, would have their own means to respond to the disadvantages they face in size asymmetry to sustain and growth their businesses. For instance, Johnsen and Ford (2008) have found that small suppliers do leverage their limited power (such as technological know-how) strategically to assist their larger customers in new product or project developments to consolidate their relationship with important buyers. The manner in which small retailers manage size asymmetry in their relationship with larger suppliers is the subject of this paper, which is set within the context of the Asian grocery industry in Australia.

The next section will review the background literature on power bases of suppliers and retailers, including how the two leverage their power bases to extract benefits from the relationship. We will then describe the research methodology, discuss the findings and conclude by offering a number of propositions as contributions to theory building.

2. LITERATURE REVIEW

2.1. Power Bases of Suppliers and Retailers

In a dyadic buyer-seller relationship, market power generally refers to the ability of the supplier or buyer to set prices profitably, either above (in the case of seller by restricting quantity supplied) or below (in the case of buyer through increase in volume purchase) competitive levels (Chen, 2008). Market power could also be derived from one party's credible threat of harm, or of withdrawing or withholding of benefits, to the other party (Foer, 2006; Clarke et al., 2002).

Viewing power from the perspective of price setting implies that the power bases of suppliers and retailers essentially depend on the number of sellers and buyers in the market as well as the nature of the relationship between sellers and buyers. As Sandford (2007) has found, when customers had a large number of sellers to choose from, sellers tend to provide better service, due to the risk of customers loss. If sellers have a number of buyers to go to, buyers will more likely to offer good prices and competitive terms to satisfy the seller (Carstensen, 2008).

In a dyadic exchange relation, when one party is able to secure a concession from the other by threatening to impose a cost, or to withdraw or withhold a benefit, if the other party fails to grant the concession, that first party is said to possess the bargaining power (Kirkwood, 2005). The ability to secure concession through threat is also known as potential (as against actual) power. Wrong (1979) contends that buyer and seller powers are vested more in their potential (i.e., in possession of the capability) than actual (i.e., exercising the capability) capability: when the other party meets the intentions of the power holder without having received an instruction to carry them out.
Viewing power from the perspective of bargaining power means that the size of one party (e.g., a supplier) vis-à-vis the other (e.g., the buyer), or the absolute size of either party, will be an influential power factor. Size asymmetry has been found to affect the levels of cooperation a small buyer could expect from a larger supplier, including the de-

gree of closeness the latter wanted in the transactional relationship with the smaller customer (Mudambi et al., 2004).

The power of size can also be reflected in a number of ways: purchase volume, purchase value, geographic reach (e.g., number of outlets a supermarket chain has), and customer base. A buyer's size may also be manifested in relation to a particular supplier's total business. For instance, Inderst and Valletti (2007) indicate that a supplier was deemed to be "economically dependent" on one buyer, if the latter accounted for more than 22% of the former's total revenues. A small buyer operating in a niche market may also hold a more important position to a supplier than a large buyer, if the small buyer has access to a specific or exclusive market segment (Lamming and Harrison, 2001). Likewise, the availability of alternative sources of supply to the buyer, and the supply of products (including own-label and branded items) that compete with the supplier's product also affect the power relationship between a seller and its buyers (Dobson and Chakraborty, 2008).

2.2 Power Play in Buyer-Supplier Relationships

In the context of a dyadic exchange relationship between buyers and sellers, power is always used opportunistically by either party to secure a better outcome at the expense of the other. Powerful buyers have been known to often draw on their buying strength to squeeze discounts from suppliers to obtain higher profit margins and also to enable them to lower prices to garner greater sales and edge out competitors (Carstensen, 2008).

The UK grocery supermarket provides an example in which large supermarket chains commonly utilize their buying power to achieve advantageous ends to the detriments of their suppliers and other smaller buyers (Mills, 2003). The threat to 'de-list' one or more weaker brand products of a supplier is one of the common tactics used (Mills, 2003). Another strategy commonly employed by large supermarket chains to enhance its buyer power is introducing own-label brands. Because supermarkets can specify product qualities (Burt, 2000) and choose where to position their brands on the quality spectrum, it is possible for them to secure large sales, even without incurring advertising expenses.

In the UK grocery market, the lowest price a supplier willing to accept when dealing with a large chain is often insufficient to yield a "normal" profit on those sales. In such situations, it is not uncommon for suppliers to recoup their deficits from sales to smaller customers. Data from the UK Competition Commission (2000) show that, for some major branded goods, small retailers pay large suppliers up to 12 percent higher than the prices paid by larger companies. Some UK supermarket chains also impose a number of retrospective measures to exploit their suppliers, including requiring compensation from a supplier when its profit on a product turns out to be less than expected; or coercing a supplier to buy back unsold items, when no written 'sale or return' agreement existed (Mills, 2003).

Suppliers, on the other hand, are not short of tactics to leverage their positional power to achieve gains. The use of advertising and branding, for example, to increase product attractiveness is a common method suppliers adopt to lift their potential selling power (Ramsay, 1994). Suppliers associated with prestigious companies, such as Rolls Royce, IBM, or Shell, or with other suppliers with technological superiority, market leadership, product innovations, quality or reliability, could conjure an image that boosts the attractiveness of the buyer's money and hence amplifies the supplier's power. Suppliers offering superior service efficiency or product quality not available from rival suppliers to the extent that their absence from a retailer's store will make consumers shop elsewhere also command considerable seller power. Dobson and Chakraborty (2008) refer to these suppliers, respectively, as "must-use" and "must-stock" brand suppliers.

In sum, asymmetry in supplier-buyer relationship is a source of power play. The literature, however, is predominantly occupied by discussion on how the larger partners opportunistically exploit this asymmetry to advantage. The opposite perspective of how the smaller parties manage this asymmetry is less well documented. This study contributes to this gap in the supplier-buyer relationship literature by examining the situations of small Asian grocery retailers in Australia using multiple case studies.

METHODOLOGY

3.1 Multiple Case Study Methodology

Our objective was to explore the less well understood topic of how small Asian grocery retailers manage their supply channels. We adopted a multiple case study approach (Eisenhardt, 1989), selecting three Asian grocery retailers in Melbourne as our cases. Because the study is exploratory in nature, a multiple case study approach was considered appropriate (Eisenhardt, 1989; Yin, 2003).

3.2 Case Selection

Through a series of dedicated search, we identified three relatively well-performing Asian grocery retailers in two different suburbs in Melbourne, Australia as our cases. All three retailers had been operating for over 10 years, but varied significantly in employment size, business (or sales) focus, as well as locational attributes (Table 1). This was done deliberately as part of the theoretical sampling strategy (Eisenhardt, 1989) to explore the effects of size on the ability of the retailers to exercise buyer power.

	GVCG	DKSAG	CHAG
Year business commenced	1995	1999	1995
Ownership	Family	Family	Family
Shop History	Bought business from brother	Bought over an existing business	Bought over an existing business
Employment Size Weekday Weekend	 - Full time - 30 - Part time - 15 - Full time - 30 - Part time - 20	 - Full time - 8 - Part time – 7 - Full time – 8 - Part time - 10	 - Full time – 2 - Part time - 1 - Full time – 2 - Part time - 2
Sale focus	- Fruits - Vegetables - Dried foods	- Fresh fish and seafood - Dried foods.	- Dried foods - Cold beverages.
Locational features	▪ Located at entrance to a wet market in a predominantly Asian suburb ▪ Surrounded by several equal-sized (big) Asian grocery retailers on same block	▪ Located at intersection of two major roads of a busy suburb, adjacent to a wet market and public car park. ▪ Only Asian grocery retailer on block	▪ Located at centre of a busy suburb, in front of a bus stop, closed to a big public car park ▪ Surrounded by a few bigger Asian grocery retailers on same block

Table 1: Profile of Three Case Asian Grocery Retailers

3.3 Data Collection

To enable an in-depth examination of each case, we employed a semi-structure questionnaire designed to explore the different ways in which the three selected Asian grocery retailers managed different groups of suppliers. The on-site interviews were conducted between July 2009 and March 2010. Except in one instance where the face-to-face semi-structured interview was conducted with the sales supervisor, all interviewees were owners (husband and wife) of the selected Asian grocery retailers.

Interviewees were invited to describe their routine interactions with their suppliers and the way they managed their supply channels under different circumstances. Interview questions were deliberately worded as broadly as possible to allow interviewees the freedom to relate their experiences with different suppliers at their own pace (Glaser & Strauss, 1967). In keeping with inductive methodology, the interviews were conducted in an interactive, conversational style with impromptu questions injected as and when clarification was considered needed. We also requested permissions from all three retailers to allow us to attend some of their negotiation sessions with suppliers as unobtrusive observers to enable us verify and triangulate the interview notes.

Unlike the case of large corporations, all three retailers did not have any formal business documents for us to consult. As such, we requested permission for follow-up visits to ensure we reached data-saturation, i.e., when no more new information became discernible (Glaser and Strauss 1967; Eisenhardt 1989). In all three cases, three to four rounds of on-site interviews were conducted in addition to short telephone clarifications in between. The time taken for each interview ranged from 45 minutes (for subsequent interviews) to over 4 hours (for first interviews). Per requests from the retailers, fictitious names are used to ensure anonymity. All interviews were taped and later transcribed for detailed analysis.

3.4 Data Analysis

Following Miles and Huberman (1984), we first conducted within-case analysis to identify unique situations and contingent factors that underpinned the supplier relationship management approaches of the three case retailers. We then performed a cross-case analysis to compare and contrast the different relationship management approaches used. From the results of the cross-case analysis, we developed propositions on small Asian grocery retailer approaches to supplier management.

4. RESULTS

4.1 Within-Case Analysis

Case Study 1: GVCG

GVCG was the largest of the three case retailers, with 30 full time employees and 15 part time workers, which swelled to 20 during weekends. By employment size, GVCG could be regarded as one of the biggest stores in the area. GVCG specialized in fruit, vegetable, and dried food retailing. Located at the entrance to a wet market in a suburb with a strong Asian presence, GVCG held a commanding positional advantage, despite the presence of a few other big Asian grocery retailers on the same block.

GVCG used its location and market position to advantage. The shop was a popular outlet for goods on consignment, such as the home-made Vietnamese and other Asian cakes and cooked food. While most home-made food suppliers would limit the amount of items consigned to Asian grocery shops, these suppliers typically asked GVCG to accept a larger quantity in return for a longer credit term. Because of its regular huge purchase volume, GVCG was able to obtain favourable credit terms and very competitive prices from many large suppliers, a feat many of the Asian grocery retailers in the area envied. GVCG had its own cold room for fruit and vegetable storage, which made this retailer an extremely popular outlet for small private farmers to consign their farm produce. This allowed GVCG to offer very competitive prices for fruits and vegetables all year round.

GVCG's sales strategy was to offer an extensive choice of Asian groceries to customers. Its aim was to be a one-stop shop for Asian groceries. GVCG welcomed all suppliers who agreed to offer competitive transaction terms and prices. In addition, GVCG used cost leadership as one of its competitive weapons to attract customers visiting the wet market. Its usual strategy was to put on sales a variety of seasonable fruits and vegetables, besides offering very competitive prices for many popular brands of dried foods and sauces. The intent of such a sales strategy was not only to attract customers but also to promote goods of different suppliers to customers at different times. This was GVCG's tactics to subtly demonstrate its retailing power to big suppliers holding exclusive supplying rights for some popular brands of dried foods.

Case Study 2: DKSAG

DKSAG was smaller than GVCG in terms of employment size. It had eight full time staff, five of whom were family members, and seven part time staff during weekdays, which increased to 10 on weekends. The shop was located at the intersection of two major roads of a busy suburb, with a large Asian community, and was close to a wet market and public car park. DKSAG was the only Asian grocery retailer on its block.

In addition to offering an extensive variety of Asian groceries, in particular dried foods, DKSAG specialized in fresh fish and seafood retailing. Being the only Asian grocery shop on the block, DKSAG's sales strategy was to offer a wide variety of Asian groceries, including fruits and vegetables. The company, however, was strategic in selectively limiting most of its merchandise to only the more popular brands. DKSAG's sales tactics was to achieve high inventory turn by selling largely popular brands at very competitive prices. Profit margin was secondary.

Because of this, DKSAG was selective in its choice of suppliers, focusing on those offering popular brands. To strengthen its relationship with suppliers of major brands, DKSAG generously offered them market information, such as saleability of different types of goods. Further, DKSAG also voluntarily made payment in advance at strategic times, such as when it wanted a big order during festive season, to gain the trust and continued support from its choice suppliers. As a result, DKSAG was able to secure very flexible payment terms and competitive pricing from its choice suppliers.

DKSAG was always cautious in using new suppliers. It typically would not agree to cash terms payment from any new dried foods suppliers. DKSAG would only place orders from new suppliers willing to offer credit terms for their supplies or accept return of goods should they prove to be less saleable. It believed in cultivating trusted new suppliers.

Case Study 3: CHAG

By employment size, CHAG was the smallest of the three case retailers. Beside the husband and wife team, CHAG only had one part time worker during weekdays. Occasionally, during busy weekends, CHAG would hire an additional casual part-time help. Location-wise, CHAG was situated at the centre of a busy suburb, in front of a bus stop, and close to a big public car park. It was, however, surrounded by a few other Asian grocery retailers on the same block. CHAG was the smallest among them.

Because of its small size, CHAG had little buying power. Though CHAG knew that the terms and prices of goods it procured from major suppliers were steeper than those offered to bigger retailers, it had always adopted a compliant attitude, accepting whatever were the stipulated terms, especially from suppliers of popular, low capital items. On the other hand, it usually resisted to increase its order quantity, despite friendly encouragement from suppliers. The exception was when suppliers were willing to grant favourable terms and competitive pricing should CHAG's order quantity increase.

CHAG's business strategy was to adopt a low-risk approach by limiting its inventory. As such, CHAG concentrated on retailing low-capital, high-percent margin, fast-turnover, and long expiry date items, such as instance noodles, fish sauces, dried foods and cold beverages. CHAG's other strategy was to bulk-break certain fast-moving, low-cost goods, such as ground nuts and cereal grains, to sell in smaller packs at a slightly higher unit price to obtain a higher margin.

CHAG was a strong promoter of all consigned items, home-made cakes and cooked food in particular. In general, suppliers of consigned items would place their supplies at retailers according to the latter's size. Because of CHAG's promotional effort, consigned food items in CHAG usually achieved strong sales. As a result, CHAG was able to convince consigned goods suppliers to put a larger than usual quantity in its shop.

To garner the trust and support of fast-moving, popular goods suppliers, CHAG habitually made advanced payment to valued suppliers. At times, it also voluntarily accepted to promote slow-moving items of unpopular brands from supportive suppliers to cultivate favours and develop long-term relationships. It also had a policy of supporting new and small suppliers, sharing market information and participating in their promotion campaigns. These suppliers usually reciprocated by giving CHAG very favourable trading terms, including full refunds for the return of unsold goods.

5. CROSS-CASE ANALYSIS

The findings of the within case analysis suggest that limited power bases are not necessarily a hindrance to business growth and development. Successful small Asian grocery retailers in Melbourne had their unique ways to strategically organize their sales activities by adjusting their retailing operations according to their strengths and weaknesses. The three case retailers, which represent companies of dissimilar buyer power due to their size and location, had very contrasting sales focus and supply channel management approaches.

The three case studies show that as the size of retailing business decreases, the tendency to fully accept supplier demands increases. GVCG, the largest of the three case retailers, succeeded in leveraging its larger-than-average buying power and its popular promotion campaigns to demand attractive credit terms and competitive pricing from larger suppliers. DKSAG, the second largest in size among the three case retailers, was not in a position to dictate terms to the popular brand suppliers. Instead, it reacted by offering market information on saleability of goods supplied and volunteering to make advance payment at strategic times to nurture the trust and continued support of these choice suppliers as a means to advance its sales specialization strategy. CHAG, the smallest of the three retailers, had little choice but to accept the terms and conditions of all its important suppliers. The manner in which GVCG, DKSAG and CHAG managed their relationship with suppliers suggests that the three exhibited what may be termed, respectively, active, reactive, and passive compliance. Accordingly, we offer our first proposition as follows:

Proposition 1: In the context of small Asian grocery retailers in Melbourne, the smaller the size of the retailing business, the greater will be its tendency to fully accept the terms of suppliers. The mode of compliance generally moves from one of active to reactive and finally passive.

Associated with their mode of compliance was the way in which the three Asian grocery retailers pitched their sales focus to sustain and grow their businesses. Due to its locational advantage and size, GVCG's strategy was to be a one-stop shop for Asian groceries. Consequently, it stocked a wide range and variety of goods to offer customers the widest possible choice of Asian groceries. It relied on cost leadership to increase business volume, staging frequent sales of seasonal fruits and vegetables to attract wet market visitors. DKSAG's business strategy, on the other hand, concentrated on offering competitive pricing on an extensive variety of Asian groceries, in particular popular brands of dried foods, sauces, fresh fish and seafood to grow its reputation. Profit margin was secondary. Its purpose was to achieve high inventory turn to reduce stocking.

CHAG specialized on sales of low-capital, high-percent margin, fast-turnover, and long expiry date items. While it was not able to offer competitive pricing due to the high cost of its supplies, CHAG devoted efforts to bulk-break certain fast-moving, low-cost goods to sell in smaller packs at a slightly higher unit price to receive a higher margin. It also focused on promoting consigned home-made cakes and cooked food to convince consigned goods suppliers that its shop was a popular outlet for their goods. CHAG, in short, adopted a low-risk, conservative approach by keeping inventory low.

From the business strategy adopted by the three case retailers, two obvious trends are discernible. The first trend relates to the way the three retailers generated value for their business. GVCG's approach may be termed value maximization: maximizing sales of all merchandize through competitive pricing. Though DASAG also attempted to obtain sales through competitive pricing, its tactics was more selective, concentrating on the more popular brands. We refer to such a value generation approach as value optimization. With regard to the method employed by CHAG, its method of bulk-breaking some fast-moving, low-cost goods to sell in smaller packs at a higher margin may be viewed as value creation. Therefore, we offer the following as our second proposition:

Proposition 2: Mode of compliance with supplier terms has an effect on the way small Asian grocery retailers generate value for their business. An active mode of compliance tends to lead to a value maximization approach, a reactive mode would gravitate to value optimization and a passive mode has a disposition toward value creation.

The second trend is linked to the perspective the three retailers confronted the market. GVCG's approach was a predictable one, given its size and market position. We regard the way GVCG maintained and upheld its position of strength as market conformance. DKSAG's style of placing profit as secondary while concentrating on selling popular brands of a wide variety of goods, including fresh fish and seafood, may be viewed as a way to transcend a competitive market. We call this market ascendency. Lastly, CHAG's line of attack, i.e., bulk-breaking goods to sell at a higher margin, typifies that of an innovative leadership: to redefine the market. We thus refer to CHAG's mode as market redefinition. This analysis leads us to our third and final proposition:

Proposition 3: Mode of compliance with supplier terms influences the way small Asian grocery retailers confront the market. Retailers engaging in an active mode of compliance would exhibit a market conformance posture; those exercising a reactive mode would portray a market ascendency attitude; while those captive to a passive mode would embrace a market redefinition stance.

6. DISCUSSION AND CONCLUSION

In a dyadic exchange relationship, the weaker of the two parties has always been assumed to be at the mercy of the stronger party, which manipulates the terms of the exchange to their benefits. What this study has uncovered is that though the weaker parties had little bargaining power, they were able to contrive appropriate responses to confront the market and generate value for their business. The results of the cross-case comparison suggest that the greater was the level of compliance (passive compliance), the more innovative the retailer became. Such findings suggest that innovative business leadership could be borne of situations of relationship asymmetry. Having less or no power in a dyadic supplier-retailer exchange relationship does not necessarily lead to a situation of despair. On the contrary, as the experiences of three successful small Asian grocery retailers in Melbourne have shown in this study, small retailers are adept at leveraging suppliers' opportunistic behaviours to confront the market and generate values for their business.

In conclusion, this research sheds light on the dynamics of business entrepreneurship in a situation of relationship asymmetry. Its major contribution is that it has uncovered that compliant behaviour may not necessarily be a constraint to business practices, as conventionally assumed. On the contrary, it could be a driver of value generation, which could lead to innovative ways to confront the market. In a situation of relationship asymmetry, the constraining effect of a compliant position could be transformed through innovative business entrepreneurship, as the three Asian grocery retailers investigated in this study have demonstrated.

7. LIMITATIONS AND FURTHER STUDY

As with all case study research, our findings have their limitations. While our theoretical sampling approach has targeted cases of different sizes with dissimilar power bases, the generalizability of our findings needs confirmation with further studies using a larger sample. Being confined only to small retailers in the Asian grocery sector in Australia, we could not affirm the applicability of our findings to other retail sectors in different socio-economic settings. Further studies on how weaker parties in different dyadic exchange relationships respond to the opportunistic behaviour of the stronger parties are fruitful areas that could augment the findings of this exploratory investigation.

REFERENCES

Burt S (2000) The strategic role of retail brands in British grocery retailing. ***European Journal of Marketing,*** 34: 875–890.

Carstensen P C (2008) Buyer power, competitive policy and antitrust: the competitive effects of discrimination among suppliers. ***The Antitrust Bulletin,*** 53(2): 271–331.

Chen Z (2008) Defining buyer power. ***Antitrust Bulletin,*** 53 (2): 241–250.

Clarke R, Davies S, Dobson P W & Waterson M (2002) ***Buyer power and competition in European food retailing***. Edward Elgar, Cheltenham.

Collins A (2002) The determinants of retailers' margin related bargaining power: Evidence from the Irish food manufacturing industry. ***The International Review of Retail, Distribution and Consumer Research,*** 12(2): 165–189.

Competition Commission, Supermarkets (2002) A report on the supply of groceries from multiple stores in the United Kingdom. Available at: http://www.competition-commision.org.uk/rep_pub/reports/2000/446super.htm#full. Accessed May 05, 2010.

Dobson P W & Chakraborty R (2008) Buyer power in the U. K. groceries market. ***The Antitrust Bulletin,*** 53(2): 333–368.

Eisenhardt K M (1989) Building theories from case study research. ***Academy of Management Review,*** 14(4): 532−550.

Foer A A (2006) ***Mr. Magoo visits Wal-Mart: Finding the right lens for Antitrust 7*****.** Working paper no. 06–07, Antitrust.

Glaser B G & Strauss A L (1967) ***The discovery of grounded theory*****.** Aldine de Gruyter, New York.

Harrison D (2004) Is a long-term business relationship an implied contract? Two views of relationship disentanglement. ***Journal of Management Studies,*** 41(1): 107–125.

Inderst R & Valletti T (2007) ***Buyer power and the "Waterbed Effect"*****.** Available at: http://www3.imperial.ac.uk/portal/pls/portallive/docs/1/7799702.PDF. 2007. Accessed April 10, 2010.

Johnsen R E & Ford D (2008) Exploring the concept of asymmetrys: Typology of analyzing customer-supplier relationships. ***Industrial Marketing Management,*** 37(4): 471–483.

Kirkwood J B (2005) Buyer power and exclusionary conduct: Should Brooke Group set the standards for buyer-induced price discrimination and predatory bidding? ***Antitrust L.J.,*** 72: 638–39.

Lamming R & Harrison D (2001) ***Small customers and larger suppliers: The potential for strategic purchasing*****.** 10th International IPSERA Conference 2001, Jonkoping, Sweden.

Miles M & Huberman M (1984) ***Qualitative data analysis.*** Sage, Newbury Park, CA.

Mills G (2003) Buyer power of supermarket. ***Agenda,*** 10(2): 145–162.

Mudambi R, Schruender C P & Mongar A (2004) How co-operative is co-operative purchasing in small firms? ***Long Range Planning,*** 37(1): 85–102.

Ramsay J (1994) Purchasing power. ***European Journal of Purchasing and Supply Management,*** 1(3): 125–138.

Sandford J (2007) ***Three essays in applied microeconomic theory*****.** Unpublished Ph.D. dissertation, University of Wisconsin, Madison.

Wrong D H (1979) ***Power: its forms, bases and uses.*** Basil Blackwell, Oxford.

Yin R K (2003) Case study research: Design and methods. London: Sage.

THE DEVELOPMENT OF LONG TERM RELATIONSHIPS BETWEEN CONSULTANTS AND PROJECT MANAGERS IN CONSTRUCTION SUPPLY CHAIN IN MALAYSIA

Nasruddin Faisol[1], *Harlina Suzana Jaafar*[2]
[1]Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, MALAYSIA
[2]Malaysia Research Centre for Logistics and Supply Chain (MaRCeLS), Malaysia Institute of Transport (MITRANS)/Faculty of Business and Management, Universiti Teknologi MARA, Shah Alam, MALAYSIA

INTRODUCTION

There is no doubt that the relationships between project managers and consultants are important for the success of a construction project. Researchers and practitioners agree that every party can play an important role if they have harmonious working relationships manifested in mutual understanding, minimal conflict, open communication, team working, fairness and a high degree of trust and commitment (e.g. McDermott et al. 2005; Barratt, 2004). In the construction supply chain, many studies have been conducted focusing the importance of integration and collaboration and issues preventing collaboration (e.g. Dainty et al. 2001; McDermott et al. 2004). However, few have examined relationship development as a process. Moreover, previous research on the importance of developing harmonious working relationships has been mainly conducted in the western cultures such as the USA, UK and other European countries. Less attention has been paid to collectivist societies such as Malaysia that put much concern on relationships (e.g. Abdullah, 1992; Goddard, 1997). This paper reports on research which explores the process of how long-term relationships develop between the consultants and the project managers in Malaysia and how those elements emerge within the process.

RELATIONSHIP DEVELOPMENT PROCESS

A number of studies have examined the process of relationship development among organisations. These include work on buyer-seller relationships (Ford, 1980; Dwyer et al. 1987; Ellram, 1991; Wilson, 1995), pharmacist-physician relationships (McDonough and Doucette, 2001), alliances learning (Iyer, 2002), and franchisor-franchisee relationships (Doherty and Alexander, 2004). Each of these bodies of literature offers insights into the nature of how relationships develop in stages. The similarities of the studies lie on the fact that relationships evolve over time through a predetermined set of phases (Ford, 1980). However, although studies on relationship development process involved contractual and non contractual relationships, there is little consensus on determining when the contractual relationships begin in a complete cycle of the relationships. For example, Ford (1980) divided the relationships into five stages (pre-relationship stage, early stage, development stage, long-term stage and final stage). Similarly, Dywer et al. (1987) identified five stages (awareness, exploration, expansion, commitment and dissolution) and Ellram (1991) five phases (preliminary phase, identify potential partners, screen & select, establish relationship and evaluation relationship). However Ford (1980) identified contractual relationships started at development stage, as compared to Dwyer et al. (1987) at commitment stage and Ellram (1991) at 'establish relationship stage'.

In the construction management literature, there have been many studies conducted emphasising the importance of integration and collaboration in construction supply chain as well as various issues that may hinder collaboration to occur (e.g. Dainty et al. 2001; McDermott et al. 2004). However, studies focusing on relationship development as a process, beginning from the early stage of the relationships to the dissolution stage have been paid less attention. Furthermore, studies conducted within a collectivist society like Malaysia have been widely neglected. Within Malaysia, it is well-known that there is a very high concern for relationships with others (Abdullah, 1992; Goddard, 1997; Abdullah and Lim, 2001). Thus, it represents a very different cultural context for examining the development of inter-firm relations. The aim of the research reported in this paper is to explore the relationship development process between projects managers and consultants in Malaysia in order to establish the applicability of existing relational models to this very different context.

RESEARCH METHODOLOGY

This study employed a qualitative method and case study design. Since the relationship development process has received little attention in the construction management literature, in-depth semi-structured interviews were deemed appropriate as there was little priori knowledge from which a more structured research instrument could be deduced. The interviews were conducted with representatives from a range of five case study organisations operating in Malaysia. In each case, the data was collected from a project manager, an architect, two quantity surveyors, and two civil and structural consultants. The main themes covered in the interviews concerned the background of the organisation, how long they have been in inter-firm relationships, and how they developed long-term relationships. The recorded interviews were transcribed verbatim and then categorised under conceptual headings. A research framework was developed following the tabulation of the research findings. A summary of the organisations taking part in the study is provided in Table 1 below. The client organisation is a large government agency which runs many development projects throughout Malaysia. The project manager (PM) has been in the contract with the client for 10 years managing these development projects.

Table 1: The Background of Informants

Position	***Background***
Project Manager (PM)	Previously, PM was the subsidiary of Client N that managed all development projects of the client throughout Malaysia. The consultants who wanted to carry out the project have to register with the PM by submitting their profile. The award was normally based on rotation. While procurement route for the contractors was based on traditional method. From mid 1990s, PM has become independent project management consultant and has been in the contract with client for 10 years.
Consultant A	Consultant A is a civil and structural firm. Two of its directors were the former staff of PM, who joined Consultant A after the firm has been in operation for a few years. Since they joined Consultant A, the firm has been awarded many projects within 10 years.
Consultant B	Consultant B is a civil and structural firm. It has managed only one of the PM's projects, but many projects with other clients.
Consultant C	Consultant C is an architect firm, who is a sole proprietor. He started his own business with the help of the PM. He is also the former staff of the PM. He has been awarded a huge number of projects within the first 5 years.
Consultant D	Consultant D is a consultant quantity surveyor firm. It business has been in operation for 8 years. It has been awarded many projects from other clients and only one project from PM.
Consultant E	Consultant E is a quantity surveyor firm. It has some experiences handling a few of PM's projects previously and has never been given any projects since then.

FINDINGS

Based on the experiences of the consultants and the project managers indicated from the in-depth interviews, the stages of relationship development were labelled with a number. Level 1 (which includes consultants B, D and E) represented the 'exploration' stage. They did not know the project manager before the relationship began. Level 2, began at the 'commitment' stage and comprised the relationships between the consultant A and the PM. Level 3 represented the relationships of the consultant C and the PM began at the 'indebtedness (*terhutang budi*) stage'. These stages are discussed in more detail below together with the other developmental stages discussed by the informants. Figure 1 shows the levels and stages of the relationship development process developed in this study.

Stage 1: Pre-relationship stage
The pre-relationship stage is where the contractual relationships between the project manager and the consultants have yet to develop. The informants suggested that

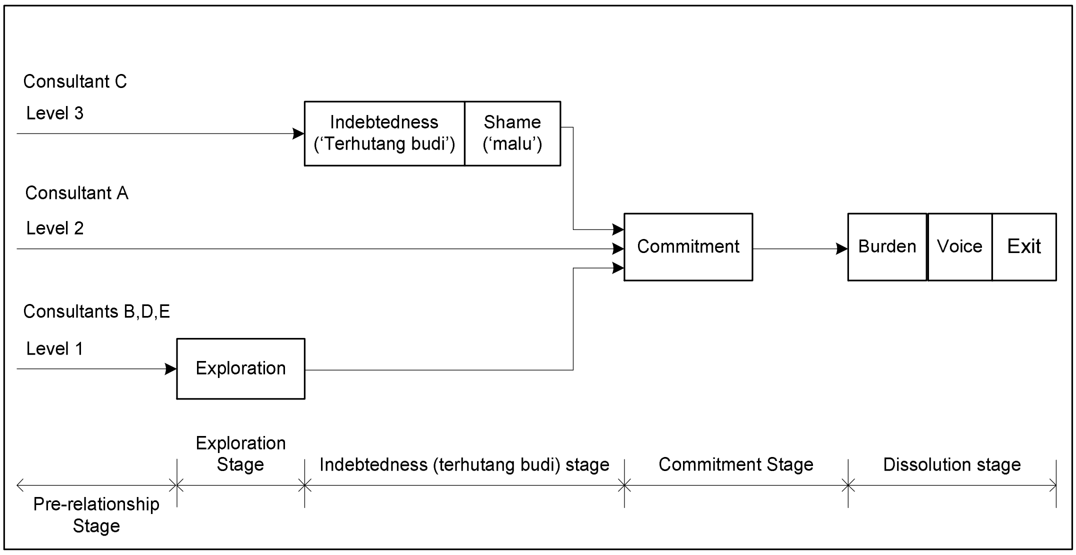


Figure 1: The Relationship Development Process between the Consultants and the Project Managers

during the early stage of relationship development, the recognition of the potential consultants was just based on their company's profile and reputation. For example, the decision to award the project to Consultant D was based on their reputation for being competent to carry out the work required. However, the project manager was also influenced by the recommendation from a member of their staff that had a personal relationship with Consultant B. As stated by Consultant B; *"…when I was given the first project, it was a continuation project of other consultant, who was insolvent. It was the PM's engineer whom I knew and he recommended (to the Board of Director of the PM's firm) me to continue the project."*

Stage 2: Exploration stage
The exploration stage takes place when the contractual relationships begin. Exploration is a trial stage, in which both parties gauge and test their compatibility, expectations, trustworthiness and commitment to the relationships. At this stage, the PM assesses the degree of each consultant's actual capability and performance in providing the service and fulfilling PM's expectations. It could also be a point in which the consultant could be trusted in conducting future projects. In relation to this, Consultant B stated that:
"…in practice, when we get a project from them (PM/client), complete the project first, then only we asked for another project. I have to perform and the good performance would be the evident of my firm's capability. The same goes to other clients; I'll be the Civil & Structure Consultant for the wet market project (east of the city centre)."
Consultant D also had a similar experience, in which he said that *"there was once in a meeting with PM, in which the PM mentioned that the PM will only give other project to us after the first project completed".*
The ability to provide excellent performance in the first project is very important to gain the PM's recognition on the consultant's capability in conducting the project. This would in turn determine the PM's willingness or unwillingness to continue giving projects in future. If the consultant is able to perform in the first project, it verifies that trust given by the project manager at the pre-relationships stage was warranted. From there, trust would develop and consequently PM would commit to give them more projects in future. The data showed that all Consultants have fulfilled their PM's expectations. However, Consultant B highlighted that performance was not the prerequisite to get projects in future. In fact, he emphasised that a consultant should know how to persuade PM and learn their interest.

'To get projects, you must lobby them and it should be for the common interest of both parties'. In fact, he said, *'you must know them personally and they know you personally. In order to get to know very closely, I have to meet and visit them regularly'*. Cons B also stressed that, *'it has been a practice that we will have lunch or coffee together either at the meeting venue or any restaurant after each meeting. We normally join them until the function is over.* The most important thing according to B was that *'we have to be very close to the decision-maker of that firm and normally he is the owner of the firm'*. These quotations show that the technical aspect were not significant in obtaining the future projects. In fact, it was the relational elements that were more vital. It also demonstrated that the decision to continue a contract was not based on the performance alone, but it was based on 'whom you know' instead of 'what you know'.

The exploration stage also occurred from the perspective of consultants to their PM. Consultant B developed trust in their PM when they did not face any problems working with the PM and they received all payments accordingly. *'PM could be trusted as a good company. In terms of payment, I trust them. I received all my payments and they never deduct fees that I suppose to get'*. This indicated that consultant B was satisfied with the PM's service and their relationships. However, dependency on the same project manager did not guarantee that the consultant would get more projects in future. Consultant E stated that *'we only have to ensure that we have good relationships with them, but that does not guarantee that we will get more projects in future. We cannot force them. We only rely on fate determined by God. In an uncertain situation, the consultant did not depend on the power of the PM in giving them projects preferring to rely on fate.*

Stage 3: Indebtedness (*terhutang budi*) stage
Consultant C entered the relationships with the PM at Level 3, i.e. the indebtedness (*terhutang budi*) stage. Indebtedness is the feelings of being in debt of kindness existed when he/she has been helped or obtained kindness from others. The owner of Consultant C was a former staff of PM and had established a long-term personal relationship. When Consultant C decided to set up his own firm, the PM offered their help in providing consultancy opportunities. The PM also agrees to incur operational expenses such as the office rental, employees' salaries payments and other expenses payments. This situation implied that the PM has placed a high degree of trust on Consultant C. When Consultant C was prepared for the relationship he said that, *'I appreciated PM because they gave me the opportunity to learn many things. I consider PM as my university. It's because I've learn many things about professional practice. If I didn't work with them, I won't be at this stage without their help'.*

However, the expenses spent on Consultant C's business were in the form of advance and Consultant C had to pay back all of these expenses when he received revenue from his projects. In addition, the PM also requested that the profits gained by Consultant C should be shared based on an agreed percentage. Thus, Consultant C's willingness to partner with the PM by sharing his profits was resulted from the concept of indebtedness (*terhutang budi*) felt by Consultant C. This situation of indebtedness makes them feel '*malu*' (literally shame) to the donor until he can repay such debts. The PM's decisions in choosing Consultant C and giving them projects continuously represented the power of the PM. Consultant C became loyal to the PM only after the PM showed their commitment to partner with Consultant C. On the other hand, PM became loyal to Consultant C due to his commitment to carry out his responsibilities as a consultant and prepared to share his profits with the PM.

Stage 4: Commitment stage
Commitment is the desire to continue the relationships in future. In this study, commitment appeared at level 2 of the relationships, in which Consultant A entered the relationships with the PM at this stage. This was because trust in Consultant A has been developed before Consultant A entered the inter-organisational relationships (two of the Consultant A's directors were former staff of the PM's firm). As a result, the PM awarded many repeat projects to Consultant A,

'after I left PM in 1995, we immediately got projects from PM, from small to big projects,' and *'trust has already existed because the relationships with PM have already been established, especially when I knew the Executive Director, Managing Director and Chief Executive Officer personally and they also knew me personally. So, trust was there for quite a long time because we were the former staff of PM'*.

Even though the interpersonal relationships with the senior management of the PM had been established, the relationships were not sufficient to form a collaborative relationship. As Consultant A stated, *'we do the work on our own and PM just monitor. Whether we deliver or not, we designed as per client's requirement.* To me, the PM's roles are quite minor'. Consultant A perceived that the PM did not play an important role in delivering the service to the client. In fact, Consultant A was heavily dependent on the client who they believed had greater power to award projects than the PM. For example, if the client felt that the consultant chosen by the PM has too many projects, client may overrule this decision by asking the PM to appoint other consultant whom of which not within the PM's consortium. As was stated by Consultant A, *'…there was a situation where Client N decided that the PM has to appoint us as the consultant instead of Consultant P because Consultant P has a lot of projects in hand (Consultant P is a member of the 'consortium')*. *So, at a certain point, we feel that we are competing with the PM. So, when we are working with the PM, we worked as a team, but at other time we have to compete with them to get the projects. These are the two situations that we faced. But, trust is still there'.*

Accordingly, there, must be trust from both parties, i.e. the project manager and Consultant A, for the relationship to develop further.

Stage 5: Dissolution stage

Dissolution takes place when loyalty of the two parties deteriorates. Loyalty begins to deteriorate when either party realised that the relationships does not benefit them in bringing in more profits and that they have better options in dealing with this problem. Consultant C was not satisfied with the proportion of profits shared and started to consider leaving the relationship after five years. He believed that he could have had higher profits if he worked independently and did not rely on the PM. As a result of dissatisfaction with the PM, his loyalty started to deteriorate. As he stated, *'I'm unhappy because for every profit that I get, I have to share with them. Whenever I get the payment, after deducting all the expenses, I still have to give them'.* His statements implied the feelings of dissatisfaction with the PM due to the burden of sharing the profits with the PM. Accordingly, Consultant C decided to exit from the partnership. However, considering the huge amount of money to be repaid by Consultant C, the PM considered instalment method of payment instead of one lump sum. The act of tolerant (*tolak ansur*) shown by the PM was one example of the good manners found in the Malay culture. However, the end of the partnership did not totally end the business relationships. PM still awarded projects to Consultant C, but not as frequently as when they were in the good relationships. This reflects an element of normative commitment on the part of the PM.

DISCUSSION

The results in this study present a number of issues worthy of discussion. Firstly, it was found that the existing inter-organisational relationship models in the literature did not accord with the Malay organisations. It is argued that there is a need for more culturally sensitive models which fit the Malay cultural context. As a result, a model that represented the Malay organisations was developed in this study. Three levels of entry to the relationships were found and they were incorporated in the model. Each level of entry differs in accordance with the degree of inter-personal relationships in the pre-relationship stage. The organisations that have no personal contact with the counterpart would enter the level 1 of the relationships. On the other hand, those who have close personal relationship would enter at level 2 (in commitment stage) or level 3 (in indebtedness stage) of the relationships (as shown in Figure 1). However, the commitment stage at level 2 and level 3 differed in that there existed two main cultural elements, indebtedness ('*terhutang budi'*) and '*malu*' (shame) at level 3. In this study, '*terhutang budi'* and '*malu*' were the pre-requisite to willingness for relationship. In the previous research, '*terhutang budi'* and '*malu*' were considered as strong values among the Malays in the perspective of socio-cultural relation (e.g. Dahlan, 1991; Goddard, 1997). However, studies that found '*terhutang budi'* and '*malu*' as the pre-requisite to relationships in the perspective of inter-organisational relationships were lacking.

Secondly, the model in this study showed that the contractual relationships between the PM and its five consultants started at various levels, i.e. the beginning of each level; exploration stage in level 1, commitment stage at level 2 and indebtedness stage at level 3. It differed from the previous models, which the contract started in the middle of the whole stages of the relationships. For example, at level 1 of this study, the contractual relationships began before the exploration stage started. The PM was willing to have the contract before receiving and experiencing any service from the consultant. Exploration did not occur before the contract started as other models. This is because PM did not buy any one-off service from the consultants before making decision to have the contract and thus, did not know the competencies of the consultants. In fact, the PM only relied on the consultants' company profile and their reputations before signing up for the contract of the projects involved.

Thirdly, the results also demonstrated that the PM's willingness to partner with the Consultant C could be viewed in the perspective of entrepreneurship to set up a new organisation. The roles of the PM did not only restricted to a normal project management consultancy but also acted as a 'venture capitalist', which involved in helping to set up, manage and oversee the founding and development of a new firm (Thornton, 1999). As a new firm, Consultant C relied on the PM's organisation for continuous projects in order to be secured in business. Accordingly, the formation of a new entrepreneur (Consultant C) was one of the examples that PM helped the Malays to actively involve in business.

Fourthly, the findings from the case study exhibited the existence of the main relational norms at every stage, i.e. power, trust and personal relationships. The power to appoint the consultants for any projects has been the main factor to continue the relationships. As indicated in the previous literature of relationships, if one party has a strong power to appoint, the party that would be potentially appointed would be highly dependent on this party (e.g. Cox, 2004). Interestingly, this study found a different perspective of dependency, in which the consultant was not highly dependent on the project manager. In fact, they were highly dependent on their fate or have faith on God's power to determine whether they would be awarded more projects or vice versa. The value that they practice from the religion they embraced has been cultivated in them and thus has emerged as their attitude in dealing with these relationships. (e.g. Abdullah, 1992; Rashid and Ho, 2003).

This study also found that trust existed at every stage of the relationship development. But the level of trust demonstrated by both parties differed at every stage (e.g. Naismith et al, 2005). For example, the project manager's trust in consultant B at the beginning of the relationships was based on recommendation from project manager's staff. Doney and Cannon (1997) describe that gaining trust through third party's definition of another is the basis for defining that other is trustworthy. Here, trust was transferred from a trusted proof source, i.e. the project manager's staff to the project managers (Milliman and Fugate, 1988). In addition, the written document indicating the rich experience of the consultants and their recognition as a chartered consultant was based on the institutional trust, in which they gained a third party certification that defines their trustworthiness and expected behaviour (Zucker, 1986; Pavlou, 2002). The level of trust would keep increasing especially when the consultant demonstrates competency and credibility in providing the service as required by the project manager in fulfilling the contractual obligations (e.g. Anderson and Weitz, 1989; Naismith et al, 2005).

The element of personal relationships seemed to be a vital factor at every stage. In a collectivist society, personal relationships could be the measure of success or failures of certain relationships. The connotation of 'whom you know' demonstrates that decisions could be based more on connections rather than on merit (Javidan and House, 2002).

Fifth, dissolution of partnership occurred when the parties involved felt that they were not receiving benefits from the partnership. However, a surprising result found in this study was that even though the consultant had already exited from the formal contractual relationships with the project manager, their long interpersonal relationships led them to continue to award projects to the consultants. It implied that through the dissolution of formal relationships, the consultant did not have to share profits with the PM and that ended the inter-organisational contractual relationships, but not the interpersonal relationships. This result differed from the previous literature, in which the business relationships ended at the dissolution stage when the parties involved started to look for other business network to continue their business.

CONCLUSION

Theoretically, the framework developed in this study (as shown in Figure 1) demonstrated that indebtedness (*terhutang budi*) and '*malu*' (shame) are two important cultural Malay values, in which they act as the antecedents to the relationship. Thus, any local or foreign parties who would like to deal with Malay organisations should receive their repayment for any helps that are given to them, whether it is in the form of tangible or intangible gift. This is because they have a strong belief that any good deeds that that they receive should be repaid. Long-term commitment emerges as consequence of these values rather than transactional requirements emerging out of contractual relationships. This study provide guidance to any foreign construction organisations who are interested to deal with and entered the construction industry market in Malaysia with regard to the specific characteristics of Malaysian construction industry market.

REFERENCES

Abdullah, A. (1992) The influence of ethnic values on managerial practices in Malaysia. Malaysian Management Review, 27 (1), 3-18.

Abdullah, A. and Lim, L. (2001) Cultural dimensions of Anglos, Australian and Malaysian. Malaysian Management Review, Vol. 36 (2), pp 9-17

Anderson, E. and Weitz, B. (1989) Determinants of continuity in conventional industrial channel dyads. Marketing Science, 8 (4), 310-323.

Barratt, M. (2004) Understanding the meaning of collaboration in the supply chain. Supply Chain Management: An International Journal, 9 (1), 30-42.

Cox, A. (2004) The art of the possible: relationship management in power regimes and supply chains. Supply Chain Management: An International Journal, 9 (5), 346-356.

Dahlan, A. (1991) Local values in intercultural management. Malaysian Management Review, Vol. 26 (1), pp 23-31.

Dainty, A.R.J., Briscoe, G.H. and Millett, S.J. (2001) New Perspectives on Construction Supply Chain Integration. Supply Chain Management, 6 (4), 163-173.

Doherty, A.M. and Alexander, N. (2004) Relationship development in international retail franchising: Case study evidence from the UK fashion sector. European Journal of Marketing. 38 (9/10), 1215-1235.

Doney, P.M. and Cannon, J.P. (1997) An examination of trust in buyer-supplier relationships. Journal of Marketing, 2 (April), 35-51.

Dwyer, F., Schurr, P. and Oh, S. (1987) Developing buyer-seller relationships. Journal of Marketing, Vol 51 (2), pp 11-27.

Ellram, L.M. (1991) A Managerial Guideline for the development and implementation of purchasing partnerships. International Journal of Purchasing and Materials Management. Vol 27 (3), pp 2-8

Ford, D. (1980) The development of buyer-seller relationships in industrial markets. European Journal of Marketing, Vol 14 (5/6), pp 339-353

Goddard, C. (1997) Cultural values and cultural scripts of Malay (Bahasa Melayu). Journal of Pragmatics, Vol. 27 (2), pp 183-201.

Iyer, K.N.S. (2002) Learning in Strategic Alliances: An Evolutionary Perspective. Academy of Marketing Science Review, No. 10 (http://www.amsreview.org/articles/iyer10-2002.pdf)

Javidan, M. and House, R.J. (2002) Cultural acumen for global manager: Lesson from Project GLOBE. Organizational Dynamic, 29 (4), 289-305.

McDermott, P., Khalfan, M.M.A. and Swan, W. (2004) An exploration of the relationship between trust and collaborative working in the construction sector. Construction Information Quaterly, 6 (4), 140-146.

McDermott, P., Khalfan, M.M.A. and Swan, W. (2005) Trust in construction project. Journal of Financial Management of Property and Construction, 10(1), 19-31.

McDonough R.P. and Doucette, W.R. (2001) Dynamics of Pharmaceutical Care: Developing Collaborative Working Relationships Between Pharmacists and Physicians. Journal of American Pharmaceutical Association, 41 (5), 682-692.

Milliman, R.E. and Fugate, D. (1998) Using trust transference as a persuasion technique: An empirical field investigation. Journal of Personal Selling and Sales Management, 8 (2), 1-7.

Naismith, N., Price, A.D.F., Dainty, A.R.J., Bryman, A., Greasley, K. and Soetanto, R. (2005) Engendering Trust in the Construction Supply Chain. Journal of Construction Procurement, 11 (2), 136-153.

Pavlou, P.A. (2002) Institution-based trust in interorganizational exchange relationships: the role of online B2B market places on trust formation. Journal of Strategic Information Systems, 11, 215-243.

Rashid, M.Z.A. and Ho, J.A. (2003) Perceptions of Business Ethics in a Multicultural Community: The case of Malaysia. Journal of Business Ethics, 43, 75-87.

Thornton, P.H. (1999) The Sociology of Entrepreneurship. Annual Review of Sociology, 25, 19-46.

Wilson, D.T. (1995) An integrated model of buyer-seller relationships. Journal of the Academy of Marketing Science, 23 (4), 335-345.

Zucker, L. (1986) Production of trust: institutional source of economic structure 1840-1920. Research in Organization Behavior, 8 (1), 53-111.

DESIGN AND IMPLEMENTATION OF AGILE GLOBAL SUPPLY CHAINS

Purvis, L., Naim, M. M. And Towill, D.
Cardiff Business School, Cardiff University, United Kingdom

1.0. INTRODUCTION

The intensive globalisation of the UK fashion sector has long been investigated. Currently, for many high street fashion retailers the decision is no longer whether to engage in foreign production, but how to organise and manage it better. However, previous studies in agile supply chain management in a global context have highlighted the fact that, in comparison to local sourcing networks, higher degrees of inflexibility can be expected. This paper explores the role of sourcing agents (intermediaries) in enhancing the responsiveness of agile fast fashion supply networks in a global context.

2.0. LITERATURE REVIEW

2.1. The Nature of Today's Fashion Markets

Modern fashion is claimed to affect everyone with its ephemera, promoting greater purchasing frequency. Customers now have more choice, are likely to be less loyal, are not prepared to accept second best and have become more sophisticated in their tastes and their approach to buying goods and services (Hines, 2001). In this context, previous studies have shown that as the fashion element of clothing products increases, so their shelf-life decreases (Forza and Vinelli, 2007). Combined with higher demand for more frequent new product introductions, this increases the level of responsiveness that companies operating in this highly volatile environment need to exhibit.

2.2. SCM in the Fashion Industry

As a result of the characteristics of today's fashion markets, high street retailers' success is a function of their ability to design products with a high fashion content, monitor demand for these, and manage a flexible and responsive supply chain that allows them to adapt quickly to any changes in demand. For items with high fashion content, identifying market needs is essential, but given the very short product life cycle, an agile supply chain able to deliver the product in a timely manner is also required. In contrast, efficiency should be pursued when dealing with functional products characterized by long lifecycles and predictable demand.

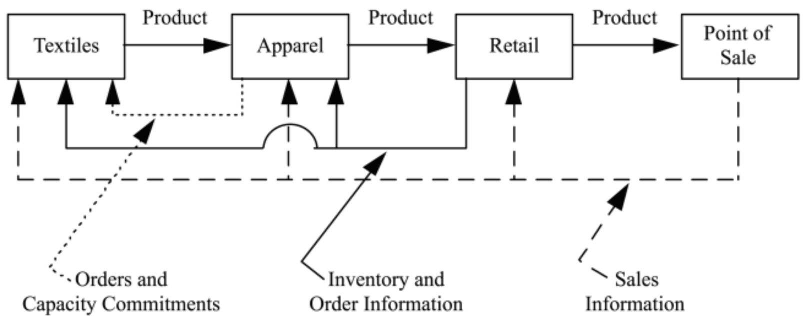


Figure 1. The Clothing Supply Chain (Source: McMichael et al., 2000)

As a result of the growing retailer concentration in the UK, which increases competitive pressures along price, the industry has been long focusing upon reducing labour costs within garment manufacture, mainly through global sourcing (Jackson and Shaw, 2001; Bruce et al., 2004). Outsourcing to further away regions, however, has also resulted in extensive and complex apparel supply chains, and consequently longer lead times. As such, experts maintain that global supply chains are more difficult to manage than domestic supply chains (Dornier et al., 1998; Wood et al., 2002) and less agile (Jin, 2004). Given the need for speed and responsiveness in the fashion industry, time expansion of the supply chain is not only undesirable, but results in an erosion of competitive advantage. The dilemma is that global sourcing can reduce the production cost, but cannot simultaneously ensure agility. As a result, companies operating in the fashion sector may use a combination of local and overseas sources of supply, which would allow them to provide a customised response to the needs of the marketplace. However, this would dramatically increase the complexity of their supply networks, which might, in turn, affect their speed to market.

Furthermore, Kopczak and Johnson (2003) state that in sectors in which product and process technology evolve rapidly and product lives are short, with each new generation of products the components and process technologies that are specified may change dramatically. Christopher et al. (2004) state that retailers have to act these days as network orchestrators, working with a team of actors closely for a while but that will, however, be disbanded and a new one assembled for the next play. However, the literature supports the view that highly complex networks are less responsive and require more resources and effort to synchronise and coordinate activities (Meepetchdee and Shah, 2007).

2.3. The Value of Intermediaries in Supply Chains

Previous studies (Popp, 2000) identified that in many global apparel supply chains there are one or more intermediaries acting as significant figures, further increasing the complexity of the networks. They normally work as agents, bridging retailers in developed nations and manufacturers in developing countries. They may also source fabrics and trimmings for manufacturers and exercise control over an integrated supply chain. Overall, they leverage their knowledge about overseas markets in sourcing and economise costs through supply chain management (Fung et al., 2007). The emergence of additional layers in the supply chains, such as intermediaries, is not a new trend, though, and has been documented as early as Alderson (1954), who identifies 4 fundamental reasons as to why it makes sense to introduce an intermediary into a chain of supply: they increase the efficiency of the exchange process by adding time, place and possession utility; enable the adjustment of the discrepancy of assortments by performing the functions of sorting and assorting; act as marketing agents to make possible the routinisation of transactions; facilitate the searching process by consumers and therefore reduce the costs of selling, transportation, inventory carrying, storage, order processing, accounts receivable/bad debts and customer service.

Though the subject of intermediation has received little attention in the operations and supply chain management literature (for some exceptions see Magretta, 1998; Popp, 2000), Fung et al. (2007) highlighted that the subject has been much more popular in the economics literature and some of the common research themes are: the changing roles and functions of intermediaries, organisational, antecedents of cooperative relationships, their service offerings, their role as an information.

From the perspective of transaction cost economics, Peng and Ilinitch (1998) argue that exporting indirectly through intermediaries becomes an attractive choice for the producer's marketing channel if the transaction costs of direct exports are higher than those of indirect exports. Transaction costs are comprised of search, negotiation, monitoring and inforcement costs (Williamson, 1985). In a global context, search costs can be high and even prohibitive for distant, unfamiliar areas. Similarly, high negotiation costs are assumed to apply due to language and cultural barriers. However, Peng and Ilinitch (1998) further suggest that monitoring and inforcement costs are comparatively low in industries where products are standardised and have a high commodity market, making indirect exports an attractive option. Conversely, differentiated goods characterised by a low commodity content and high degree of value added, such as high fashion items, are less likely to be traded by an intermediary.

However, two opposing views seem to exist in the literature regarding the effect of environmental uncertainty on intermediated exchange relationships. One view posits that when faced with high uncertainty, firms will coordinate their activities more closely in an attempt to reduce uncertainty (Pfeffer and Salancik 1978) through direct exchanges and long term partnerships. The other view argues that firms attempt to maximize their flexibility in uncertain environments by reducing their reliance on individual relationships (e.g., Heide 1994) through frequent use of intermediated relationships. To date there are no empirical studies attempting to link the existence of intermediaries in supply chains and the content of their service offerings to the degree of volatility in the market they operate. As such, this paper concentrates on exploring when and how the business operations of the intermediary can enable its customers to capture value by taking advantage of the service and problem-solving capabilities it offers.

3.0. METHODOLOGY

Case studies of 2 UK based specialist high street fashion retailers were conducted, as the case study is a well-recognised methodology for exploring areas where theory is still developing (Yin, 2003). Their product offering ranged from functional, low fashion content items with long life cycles and predictable demand (e.i. white T-shirts) to high fashion items with a shelf life of up to 6 weeks and a very volatile demand. The retailers managed an extensive global network of garment manufacturers, textile producers, textile finishers and printers, trim manufacturers, carriers, brokers, etc. Each case consisted of interviews with managers directly involved in supply chain management decisions, supported by documentary evidence. In total, 6 semi-structured interviews were conducted. Data was further collected through observations and site visits, an industrial workshop and consultation of key documentation and publications.

4.0. FINDINGS

Across the 2 retailers' product offerings, 3 product categories could be identified:

- *Low Fashion Items* (shelf life of 6 months to 2 years) - served by supply networks employing close, stable relationships with global suppliers;
- *Mid Fashion Items* (shelf life of 3 to 6 months) – two different sourcing scenarios were encountered here:
  I) A small minority of items was served by flexible UK-based suppliers with which strong partnerships existed;
  II) The large majority of the items were served by rapidly reconfigurable networks employing adversarial relationships with overseas garment manufacturers;
- *High Fashion Items* (shelf life of up to 6 weeks) – served by rapidly reconfigurable global networks which also required high levels of flexibility from the garment manufacturers.

As a result, the retailers designed and managed four different types of pipelines to adequately service their markets, corresponding to the 4 product categories identified above. These scenarios have been summarised in Table 1 and are detailed below.

	Basic, Low Fashion Items	**Mid Fashion Items (UK Supply)**	**Mid Fashion Items (Global supply)**	**High Fashion Items**
Rate of new product introductions	Low	Medium	Medium	High
Regularity of demand	High	Medium	Medium	Low
Suppliers' location	China, India, Romania	UK	China, East. Europe	East. Europe, Turkey
Intermediaries used	No	No	Yes	Yes

Table 1. Supply pipelines employed by the 2 fashion retailers

4.1. Low fashion items - The demand for functional products, such as black tights or white T-shirts, was stable and predictable for both retailers. These products had a long life cycle and the design alterations were rare from one season to another. The volumes sold per SKU were high and they mainly competed on cost. Stable networks with collaborative partnerships were employed and this led to the creation of typically lean supply chains focused on cost minimisation. Sourcing was committed up to one year in advance, and the search for low labour costs meant that global suppliers were always used. Production of these items would be placed in a mix of countries with various strengths, such as very low labour costs (Vietnam and the Philipines), high quality (China) or more favourable trade agreements (Eastern Europe).

4.2. Mid fashion items (UK supply) - This sourcing strategy was employed by retailer A for a small proportion of their knitwear range. These were seasonal products with a higher fashion content, which attracted higher profit margins. They were technically complex products which were woven in one piece by a capital-intensive UK based garment manufacturer. The products' life cycle would average 6 months (one season), after which the line would be discontinued and any left-over stock would be marked down, incurring significant losses. A wide choice of product designs, colours and sizes was made available, which diluted demand across the product range and increased the need for small, frequent deliveries. Time compression and efficiency were mainly achieved through greater sharing of information and integrated logistics systems. No intermediaries were used in this pipeline.

4.3. Mid-fashion items (Global supply) - The majority of the retailers' product range was mainly made up of woven products, the manufacturing of which was a much more labour intensive process. These would be designed up to 6 months before each season would be due to start, once information from designers fashion shows and trend annalists would be gathered. The 6 months design cycle was dictated mainly by the long lead times imposed by the fabric suppliers. With an increasing number of new products introduced each season and reduced volumes per SKU, the pool of skills required for clothing manufacturing was becoming increasingly complex, requiring a larger network of suppliers every season. And due to the high UK labour costs, combined with reduced local capacity availability, the supply networks used were almost exclusively global in nature. The apparel suppliers used were characterised by high labour intensity, small average plant size and relatively unsophisticated technology used. On average, over 300 garment manufacturers would be used by each retailer each season.

In order to reduce the complexities associated with global sourcing and the continuous need to restructure the supply network, the common norm for sourcing these items was to make use of indirect sourcing through intermediaries. The intermediaries had access to large suppliers' networks in the area they were serving, which allowed for the rapid identification and utilisation of spare manufacturing capacity (see Figure 2).

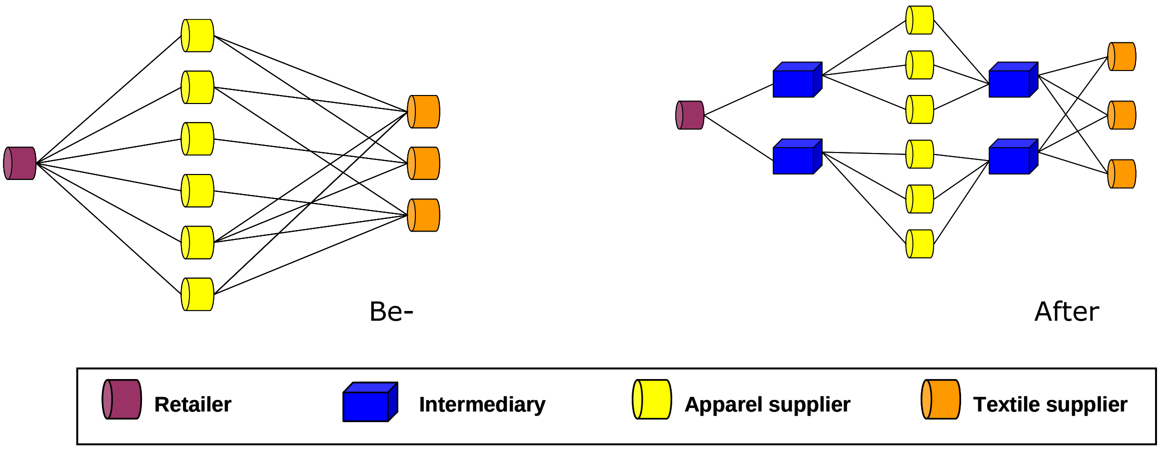


Figure 2. Supply chain structures before and after the use of intermediaries

In these networks, direct sourcing through the establishment of long-term partnerships with a small number of more flexible suppliers was perceived as likely to reduce the retailers' market-orientation capabilities to flexibly and responsively cater for a diverse, fast moving fashion market. The intermediaries' strategy of not owning any production facilities kept the supply chain flexible and adaptable, encouraging the constant search for flexible, quality-conscious and cost-effective producers. The information and material flows across these supply pipelines is illustrated in Figure 3.

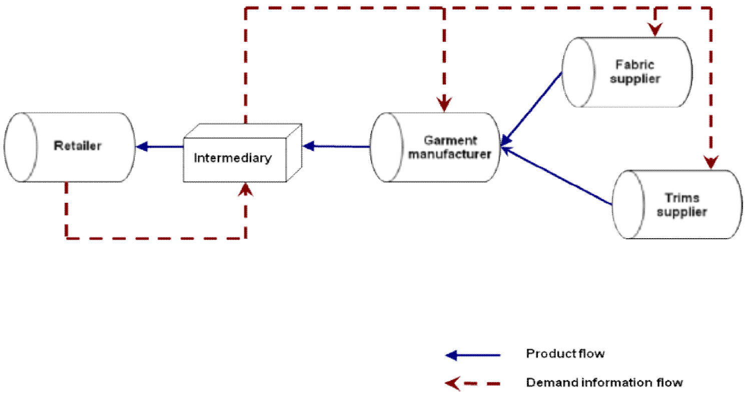


Figure 3. Global sourcing through trade intermediaries

The intermediaries were engaged in all phases of apparel manufacturing, assisting the fashion suppliers in both the design of new products, as well as the design and management of the supply systems necessary to bring these new products to the marketplace: new product design, raw materials sourcing, apparel manufacturing and distribution of the finished goods. Fabric and trims were also sourced through the intermediaries, with raw materials delivered straight to the manufacturer's facilities.

The 'Lohn' Model

An alternative sourcing model (the 'lohn' model) was identified in the pipelines used to source mid-fashion items from some of the Eastern European suppliers. In these pipelines, the intermediary would source all the raw materials required for the manufacture of a particular product, coordinate their arrival to its own warehouse and then organise their delivery as a 'bundle' to the manufacturer's facility (Figure 4). This process was mainly employed when the raw materials required were manufactured in a different county than that in which the garment manufacturer operated and the apparel supplier lacked both the operational and financial ability to engage in global sourcing. This sourcing model increased the flexibility of the total supply pipeline while making use of low cost suppliers with limited capabilities.

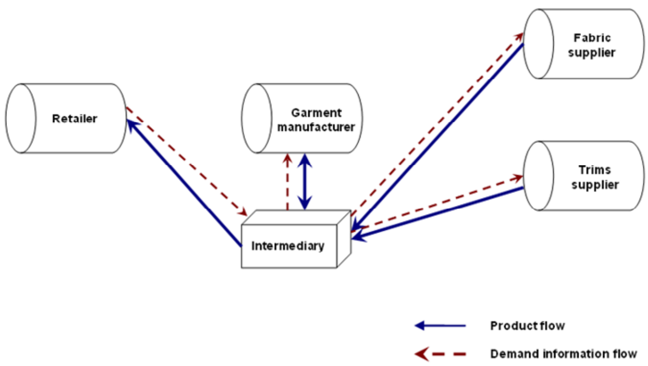


Figure 4. The Lohn Model

4.4. High Fashion Items - The retailers' seasonal product range offer also allowed for quick new product introductions designed as a response to shifts in popular culture and creating significant demand for a fashion style or trend. For these 'high fashion' items with very short shelf lives (averaging 3 to 6 weeks), forecasts were impossible to be made. As a result, the 2 retailers had to be extremely agile in capturing emerging trends, designing new products and quickly bringing them to the market. As such, lead-time reduction was key to the fashion retailers' success. Even for these items, with a much shorter shelf life, the retailers preferred global sourcing to local producers. Some of the reasons quoted for this were the lack of skilled manufacturers in the UK, the reduced local availability of fabrics and trims, high labour costs and very limited capacity still available. Eastern Europe and North Africa were the preferred sources of supply, mainly due to their proximity to the UK. To minimise the risk of obsolescence, small volume deliveries were required on a frequent basis. This required a high level of volume flexibility from the supply network and increased the need for dynamic capacity management, including the ability to add or reduce capacity at an existing facility, add or eliminate facilities, or source additional capacity at very short notice. The same sourcing practice of auctioning out production through trade intermediaries was used, allowing for the quick redesign of the supply chain on an ad-hoc basis.

5.0. FINDINGS AND CONCLUSIONS

5.1. Indirect Sourcing and the Globalisation of Fashion SCs

Previous studies have highlighted that in global supply chains lower degrees of flexibility can be expected, mainly due to a firm's inability to transfer production from one plant to another and its inability to successfully respond when capacity is constrained (Radjou, 2002). However, our case study findings reveal that retailers in the fashion industry still mainly make use of global sourcing but strive to limit interdependence and retain the ability to easily switch partners. This flexibility will result in a more intensive capacity utilization resulted from industry-wide sharing, higher risk alleviation capabilities and higher levels of customer sensitivity. Achieving this level of flexibility in a global environment, however, was only made possible through the use of intermediaries, who assisted the retailers in sourcing, supplier quality control, shipping management and distribution. They had detailed local knowledge of financial, managerial and technical capabilities of individual manufacturers in the area they were serving, as well as spare capacity available at very short notice. This knowledge helped to integrate a highly segmented production structure and accelerate the pace of production.

At the same time, through the employment of intermediaries the retailers' ability to coordinate inter-firm scale and scope economies was greatly enhanced. The concern was to achieve both economies when orders tended to be small and changes in design frequent (Hsing, 1999). As such, through intermediaries consolidating orders from different customers before placing them with a specialised manufacturer, as well as consolidating orders placed with different manufacturers before shipping to the UK, significant cost savings were achieved. From a transaction cost economics perspective, our results show that intermediaries were more knowledgeable about the foreign markets (lowering retailers' search costs), had superior negotiating capabilities (lowering their negotiating costs) and were used for supplier quality control and to take title of the goods produced (lowering the retailers' monitoring and enforcement costs).

However, for items with lower levels of demand variability which were produced in large volumes, as well as those items produced in the UK, direct sourcing and long term partnerships were employed. This confirms findings from previous studies (Shin, 1989, Klein et al, 1990) which highlighted that the value-added contribution of the intermediary will be correlated with the uncertainty or risk inherent in the particular exchange setting.

5.2. Indirect Sourcing and Time Compression in Fashion SCs

To enable a quick response to rapid changes in market trends, fashion retailers needed suppliers with the capability to manufacture the product required, but who were also able to provide the logistical know-how to find all the parts needed for the finished product and then deliver it to the UK. Thus, they required more advanced full-package companies (intermediaries) who, in turn, may subcontract out these orders to other local firms. The product development process, for example, was the point at which the retailer would be able to address a number of factors, such as the choice of fabrics and trims, flexibility of delivery system required in order to match consumer demands, the size of batches to be processed to reduce risks, ways of bringing design and colouring decisions closer to the point of sale, ways of reducing the total cost impact of product development. Intermediaries would offer to the fashion retailers assistance in bringing people with different areas of expertise together, including representatives from the retailer, the clothing manufacturer, the textile supplier, the dyer/printer and the yarn and fibre manufacturers. They would also source raw materials on behalf of the retailer and arrange delivery of the finished product to the retailer's UK based distribution centres. This led to shorter new product development processes, increased delivery speed and greater confidence in delivery reliability, all critical aspects for increased competitiveness in the sector. As such, the intermediaries' ability to manage effectively their linkages with upstream suppliers and downstream customers through the integration of key business processes distributed among a network of independent actors accelerated time to market and was their main source of competitive advantage. The use of intermediaries also gave retailers increased visibility further upstream the supply pipelines and opened-up markets for local suppliers.

5.3. Indirect Sourcing and Complexity in Fashion Supply Chains

The literature review has highlighted the fact that while benefiting from advantageous cost structures, global supply chains can also become increasingly complex to manage, not least in respect of longer distances, supplier selection, evaluation and management (Vokurka et al., 1996; Doyle et al., 2006). Corroborated with high levels of innovation, dependent on high levels of supply flexibility, our findings have highlighted that most of these challenges were greatly reduced through the employment of trade intermediaries. However, products with more stable demand allowed for long-term agreements and trust relationships to develop through direct sourcing.

With regard to the number of actors in the chain, the literature also supports the view that while a larger and more varied supply network may be sought to improve the product range dimension of agility, this increases network complexity which is counter to improving agility (Milgate, 2001; Prater et al., 2001). However, our findings reveal that through indirect sourcing retailers benefited from more stable relationships with the few intermediaries used on a regular basis, rather than the loose relationships that they previously had with the myriad of suppliers used on an on-off basis (see Figure 2). However, the intermediaries' main source of competitive advantage stemmed from the knowledge gap separating potential buyers and suppliers (Nayyar, 1990). Information asymmetries existed between buyers and sellers in these networks, which the intermediary was able to exploit. In time this would possibly diminish, but to reduce the pressure for their elimination the intermediaries were engaging in relation-specific investments that created higher exit barriers for their clients.

To conclude, our paper shows that the global, flexible and responsive supply chain is not an unattainable goal. Instead, it is becoming a necessity as customers become more demanding in terms of both service and cost. This, however, has led to the retailers replacing the extant linear supply chain relationship model that dominates most sectors (Ritchie and Brindley, 2000) with a more amorphous supply network model. In essence, fashion retailers recognised that overseas intermediaries are better equipped to manage all aspects of the sourcing, production and delivery process when high levels of responsiveness and an ability to build flexible alliances at short notice were required, while only engaging in direct sourcing for products with more stable demand profiles. This, however, also restricted their competitive edge, which was now focused towards the management of activities further down the supply chain, such as retailing and branding and increased their dependence on the use of global intermediaries. In long term, this could encourage opportunistic behaviour.

REFERENCES

Alderson, W. (1954), 'Factors governing the development of marketing channels', in Clewett, R.M. (Eds), Marketing Channels for Manufactured Products, Richard D. Irwin, Inc., Homewood, IL, pp.5-34.

Birtwistle, G., Clarke, I. and Freathy, P. (1998), 'Customer decision making in fashion retailing: a segmentation analysis', International Journal of Retail & Distribution Management, vol.26, no.4, pp.147-154.

Bruce, M., Daly, L. and Towers, N. (2004), 'Lean or agile? - A solution for supply chain management in the textiles and clothing industry', International Journal of Operations & Production Management, vol.24, no.2, pp.151-170.

Christopher, M., Lowson, R. and Peck, H. (2004), 'Creating agile supply chains in the fashion industry", International Journal of Retail & Distribution Management, vol.32, no. 8/9, p. 367.

Dornier, P.P., Ernst, R., Fender, M. and Kouvelis, P. (1998), 'Global operations and logistics: Text and cases, John Wiley & Sons, Inc., New York.

Doyle, S., Moore, C. and Morgan, L. (2006), 'Supplier management in fast moving fashion retailing', Journal of Fashion Marketing and Management, vol.10, no.3, pp.272-281.

Forza, C. and Vinelli, A. (1996), 'An analytical framework for the change of the apparel design processes towards Quick Response', International Journal of Clothing Science and Technology, vol.8, no.4, pp.28-43.

Fung, P., Chen, I. and Yip, L. (2006), 'Relationships and performance of trade intermediaries: An exploratory study', European Journal of Marketing, vol.41, no.1/2, pp.159-180.

Heide, J. B. (1994), 'Interorganizational governance in marketing channels', Journal of Marketing, 58, 71-85.

Hines, T. (2001), 'Globalisation: An introduction to fashion markets and fashion marketing' in Fashion Marketing – Contemporary Issues, Butterworth-Heinemann, Oxford.

Hoole, R. (2005), 'Five ways to simplify your supply chain', Supply Chain Management: An International Journal, vol.10/1, pp.3-6.

Hsing, Y. (1999), 'Trading companies in taiwan's fashion shoe networks', Journal of International Economics, vol.48, pp.101-120.

Jackson, T. and Shaw, D. (2001), Mastering fashion buying and merchandising management, Palgrave, Basingstoke.

Jin, B. (2004), 'Achieving an optimal global versus domestic sourcing balance under demand uncertainty', International Journal of Operations & Production Management', vol.24, no.12, pp.1292-1305.

Klein, S., Frazier, G. and Roth, V. (1990), 'A transaction cost analysis model of channel integration in international markets', Journal of Marketing Research, 26, May, pp.196–208.
Kopczak, L and Johnson, M. (2003), 'The supply-chain management effect', MIT Sloan Management Review, vol.44, no.3, Spring.

Magretta, J. (1998), 'Fast, global and entrepreneurial: supply chain management, Hong Kong style', Harvard Business Review, September-October, pp. 103-14.

McMichael, H., Mackay, D. and Altman, G. (2000), 'Quick Response in the Australian TCF Industry – A case study of supplier response', International Journal of Physical Distribution & Logistics Management, vol.30, no.7/8, pp.611-626.

Meepetchdee, J. and Shah, N. (2007), 'Logistical network design with robustness and complexity considerations', International Journal of Physical Distribution Logistics Management, vol.37, issue 3, pp.201-222.

Meijboom, B. (1999), ‘Production-to-order and international operations – A case-study in the clothing industry’, International Journal of Operations & Production Management, vol.19, no.5/6, pp.602-619.

Milgate, M. (2001), ‘Supply chain complexity and delivery performance: An international exploratory study’, Supply Chain Management, vol.6, issue ¾, pg.106.

Nayyar, P. R. (1990), ‘Information asymmetries: a source of competitive advantage for diversified service firms’, Strategic Management Journal, 11, pp.513–19.

Peng, M.W. and Ilinitch, A.Y. (1998), ‘Export intermediary firms: a note on export development research’, Journal of International Business Studies, Vol. 29 No. 3, pp. 609-20.

Pfeffer, J., and G. R. Salancik (1978). The External Control of Organizations: A Resource Dependence Perspective. New York: Harper and Row.

Popp, A. (2000), ‘Swamped in information but starved of data: Information and intermediaries in clothing supply chains’, Supply Chain Management: An International Journal, vol.5, no.3, pp.151-161.

Prater, E., Bichl, M., Smith, M. (2001), ‘International supply chain agility: tradeoffs between flexibility and uncertainty’, International Journal of Operations & Production Management, vol. 21, no.5/6, pp.823.

Radjou, N. (2002), ‘Executive overview: Adaptive supply networks’, Forrester TechStrategy, February.

Ritchie, B., & Brindley, C. (2000), ‘Disintermediation, disintegration and risk in the SME global supply chain’, Management Decision, 38 (8), pp.575-583.

Shin, K. S. (1989), ‘Information, transaction costs, and the organization of distribution: the case of Japan’s general trading companies’, Journal of the Japanese and International Economies, 3,292–307.

Vokurka, R.J., Choobineth, J. and Vadi, L. (1996), ‘A prototype expert system for the evaluation and selection of potential suppliers’, International Journal of Operations & Production Management, vol.16, no.12, pp.106-127.

Williamson, O. (1985), The Economic Institutions of Capitalism, Free Press.

SECTION 9 – DESIGN CONFIGURATION OF SUPPLY CHAINS

CLOSED LOOP SUPPLY CHAIN SYSTEM WITH ENERGY, TRANSPORTATION AND WASTE DISPOSAL COSTS

P. Hasanov[a,b], *M.Y. Jaber*[b], *S. Zanoni*[c], *L. Zavanella*[c]

[a] Department of Industrial Engineering, Qafqaz University, Baku, Azerbaijan

[b] Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, ON, Canada M5B 2K3

[c] Department of Mechanical and Industrial Engineering, Università degli Studi di Brescia, Via Branze, 38, I-25123, Brescia, Italy

ABSTRACT

Purpose:

Almost all of the inventory models in the literature for closed loop supply chains ignored energy, disposal and transportation costs. In modern manufacturing systems, energy acquires a strategic role. It sustains the levels of productivity and the efficient use of natural resources. Transportation includes modes used and distances travelled in the delivery of goods to markets (customers) and when collecting used items from the market for recovery purposes. Ignoring transportation costs may result in biased inventory decisions. In addition, not all the items collected from the market are reparable. Some will eventually be disposed. Disposal options remain to be limited; e.g., incineration or land fill, where both options are financially and environmentally costly. These factors have compelled supply chain practitioners to look for solutions that reduce the energy, transportation and waste disposal costs that help improve their firms' competitiveness and sustainability. Such solutions impact firms inventories and management policies. This paper introduces a closed loop supply chain model, looking jointly at the economic value and energy content of the products; it also aims at offering a novel framework for dimensioning lot sizing policies which are based on both economic and energy implications in the production process.

Research approach:

The closed-loop supply chain system investigated in this paper assumes a single product that consists of a forward and a reverse supply chains. In the forward supply chain, raw materials are manufactured into items, while the reverse supply chain, used items are collected and remanufactured into 'as-good-as new' items. This paper describes a system similar to that of Ritcher (1996a), which was further developed by Teunter (2004), except for accounting for the costs stressed above. The mathematical model developed in the paper minimises the sum of the classical inventory, energy, transportation and disposal costs of a simple closed-loop supply chain system.

Findings and Originality:

A mathematical model of the closed loop supply chain system with energy, transportation and disposal costs is developed, numerical examples provided with results discussed. The developed model was also compared to that of Ritcher (1996) to stress the importance of accounting for energy, transportation and waste disposal costs.

Research impact:

The numerical results emphasise that, while introducing energy, transportation and disposal costs in supply chain modelling increases sustainability of a production-inventory system due to the strict link between energy, transportation and disposal on one hand and the with environment on the other hand.

Keywords: Closed loopy supply chain, energy and inventory, sustainability, EOQ with repair

1. INTRODUCTION

Managing inventory in reverse chains (backward flow) has been stressed in several studies (e.g., Fleischmann et al., 1997). Although the production/repair EOQ model first appeared in the 1960's, it was not until the 1990's with the work of Ritcher (1996a,b) that it has been solved analytically. Richter developed an EOQ model where demand is fulfilled from a serviceable stock (that contains produced and recovered items), where recovered (e.g., repaired, remanufactured) items are considered as-good-as-new and used items are collected from the market at a constant rate. The model of Richter has been investigated for different scenarios settings, some of these works are those of Dobos and Ritcher (2004,2006), Tuenter (2004), Konstantaras and Papachristos (2006,2007), El Saadany and Jaber (2008, 2010), Jaber and Rosen (2008), and Jaber and El Saadany (2011).

The production/recovery models in the literature ignored energy, disposal and transportation costs. Although it is recognised that these costs hold and represent an important part of the total costs in a supply chain. Energy is a core component in developing economies and improving the living standards of societies. Energy sources are either renewable or non-renewable. Using a non-renewable energy source depletes natural resources (e.g., fossil fuel) making them scarce and expensive. Thus, the use of renewable (e.g., wind) energy resources is increasing as they are environmentally friendly and their technologies are becoming more economical. When evaluating different technologies, the cost of generating electricity must also consider the external costs to human health and the environment (Sahin, 2004).The results from Sahin (2004) showed that generating electricity from wind energy was the least costly and the friendliest to the environment than the other energy options. El-Kordy et al.(2002) proposed a lifecycle cost approach to evaluate the economics of using renewable and non-renewable energy resources used to generate electricity. They suggested considering the external cost of systems emissions in their analysis. Their results were in line with those of Sahin (2004). A study on the use of wind energy in Vietnam, Khan (2006) showed that it has ecological, social and economical benefits.

Transportation costs are incurred when delivering products to the market (customers) and when collecting used items from the market for recovery. Ignoring these costs may result in biased inventory decisions.

Using transportation modes that run on conventional energy is also a concern as this energy is costly and damaging to the environment. Hybrid vehicles are starting to emerge; however, the technology is not yet available to support long-haul trips.

In addition, not all the items collected from the market are reparable. Some will eventually be disposed. Disposal options remain to be limited; e.g., incineration or land fill (Dijkgraaf and Vollebergh, 2004). Both options are financially and environmentally costly (e.g., Carlee 1986., Baetz B.W. et., al.,1994, Staikos and Rahimifard, 2007).

The reminder of this paper is organized as follows. Section 2 presents the assumptions and notations. Section 3 is for mathematical modelling by considering a mixed strategy of renewable and conventional energy, transportation and waste costs. Section 4 provides some numerical examples and discussion of results. Section 5 resumes results and indicates some further development.

2. ASSUMPTIONS AND NOTATIONS

The assumptions and notations adopted in this paper are mainly the same as those of Ritcher (1996 a,b), except for the parameters associated with energy, transportation, and waste.

Assumptions:

1. A single product case with perfect quality
2. Instantaneous production and recovery rates
3. Demand known and constant
4. Constant collection rates for previously used manufactured and remanufactured items
5. Lead time is zero

6. Unlimited storage capacity is available
7. Infinite planning horizon

Notations:

Input parameters

d: constant demand rate
S_r: set up cost for a remanufacture cycle
S_p: set up cost for a manufacture cycle
h : holding cost for the serviceable stock ($/unit/unit of time)
h_u: holding cost for the reparable stock ($/unit/unit of time)
pw: a subscript representing the present worth of a cost factor
C : capital cost (initial capital expense for equipment, system design, system engineering and installation)
M : operation and maintenance costs (salaries for operation, inspection and insurance)
F : fuel cost
X : external costs including damage prevention or damage cost
S : the salvage value of the system
A : transportation cost
WC:landfill cost

Decision variables

x : lot size
T: length of the time interval ($^x/_d$)
β : repair rate
m : number of remanufacturing cycles in an interval T
n : number of manufacturing cycles in an interval T
α : waste disposal rate $(1-\beta)$
θ : percentage of renewable energy, ($(1-\theta)$ percentage of conventional energy)

3. MATHEMATICAL MODEL

Ritcher (1996a, b) ignored the costs of energy, transportation, and waste . Richter's EOQ repair and waste disposal system is depicted in Figure 1, where two stocks are considered: serviceable and reparable. The serviceable stock is for storing new and repaired items, while the reparable stock is for storing collected used items. During time interval T there are m remanufacturing and n production cycles.Energy costs parameters used in developing the model are adopted from El-Kordy et al. (2002), who considered external costs while analysing the life cycle cost (LCC) of different energy generation systems (see Appendix for details). He described external costs as human health and the environment costs, and pollution costs, which are not reflected in the price of the electricity. Life cycle cost is determine as $LCC = C_{pw} + M_{pw} + F_{pw} + X_{pw} - S_{pw}$ (according to the study of Sahin, 2004). Moreover, Baetz et al. (1994) identified landfilling cost (WC) as total cost of collecting, transporting and disposing waste,, which we refer to as the waste disposal cost (WC). Finally, we assume that transportation cost (A) between locations to be known and fixed.

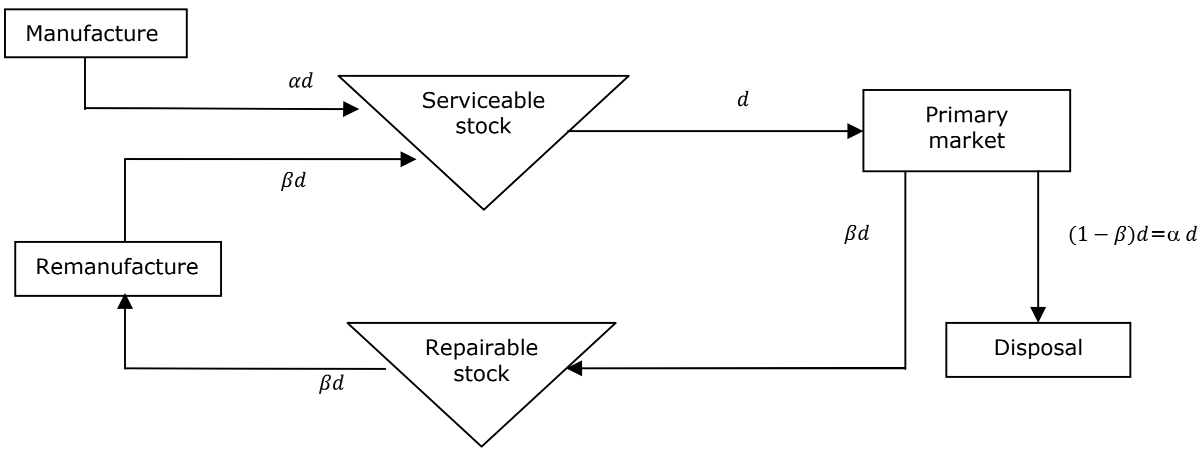


Figure 1: Material flow for a production and a remanufacture system (Richter, 1996a,b)

We assume that necessary electricity is generated by wind energy (renewable energy) and conventional steam fuel oil fired energy (conventional energy).
The total cost per replenishment cycle is the sum of setup costs for the remanufacturing and production batches $(mS_r + nS_p)$, renewable and non-renewable energy costs, costs for the remanufacturing and production, landfill and market ($\theta \sum_i^6 LCC$, $(1-\theta)\sum_i^6 LCC$) respectively, where ($k =$ wind energy, conventional steam fuel oil fired energy costs), transportation costs for the transportation of products between each pair of locations $(\sum_j^5 A_j)$, cost of the waste (WC), the holding cost for items in the serviceable stock $\left(\frac{h}{2d}\left(\frac{x^2\alpha^2}{n} + \frac{x^2\beta^2}{m}\right)\right)$, and the holding cost of items in the repairable stock $\left(\frac{h_u\beta T x}{2} + \frac{h_u x^2\beta^2(m-1)}{2dm}\right)$.
Thus, the total cost function can be written as:

$$TC = mS_r + nS_p + \theta \sum_i^6 LCC + (1-\theta)\sum_i^6 LCC + \sum_j^5 A_j + WC + \frac{h}{2d}\left(\frac{x^2\alpha^2}{n} + \frac{x^2\beta^2}{m}\right) + \frac{h_u\beta T x}{2} + \frac{h_u x^2\beta^2(m-1)}{2dm} \quad (1)$$

The average cost per unit of time is:

$$\frac{TC}{T} = \frac{d}{x}\left(mS_r + nS_p + \theta \sum_i^6 LCC + (1-\theta)\sum_i^6 LCC + \sum_j^5 A_j + WC\right) + \frac{x}{2}\left(\frac{\alpha^2}{n} + \frac{\beta^2}{m}\right)h + h_u\beta + \frac{h_u\beta^2(m-1)}{m} \quad (2)$$

The cost of function Eq. (2) is convex and differentiable in x. The optimal lot size that minimizes Eq. (2) is determined by setting the first derivative of Eq. (2) equal to zero and solving for x to get:

$$x^*(m,n,\alpha,\theta) = \sqrt{\frac{2d\left(mS_r + nS_p + \theta \sum_i^6 LCC + (1-\theta)\sum_i^6 LCC + \sum_j^5 A_j + WC\right)}{\left(\frac{\alpha^2}{n} + \frac{\beta^2}{m}\right)h + h_u\beta + \frac{h_u\beta^2(m-1)}{m}}} \quad (3)$$

Substituting Eq. (3) in Eq. (2) reduces it to:

$$TC(m,n,\alpha,\theta) = \sqrt{2d\left(mS_r + nS_p + \theta \sum_i^6 LCC + (1-\theta)\sum_i^6 LCC + \sum_j^5 A_j + WC\right)\left(\left(\frac{\alpha^2}{n} + \frac{\beta^2}{m}\right)h + h_u\beta + \frac{h_u\beta^2(m-1)}{m}\right)} \quad (4)$$

4. NUMERICAL EXAMPLE

In this section, a numerical analysis is presented to show the applicability of the model developed in the previous section. The basic parameters for the model were adopted from Ritcher (1996a,b), while life cycle costs of renewable and non-renewable energy (LCC), transportation costs between the locations (A), and landfill costs parameters were collected from other studies (Baetz and Neebe, 1994; El-Kordy et al., 2002).

In the numerical example we adopt the same values for the input parameters as those of Ritcher (1996), where $S_p = 20$, $S_r = 100$, $d = 10$, $h_u = 4$, $h = 6$, $\alpha = 0.5$. New parameters, i.e. renewable energy cost and non-renewable energy cost, are taken from the study of El-Kordy et al. (2002) where $LCC^w = 1.8085$ (wind energy cost for locations), $LCC^{fo} = 5.4256$, (conventional steam fuel oil fired energy cost for locations), while disposal costs parameters are taken from study of the Baetz and Neebe (1994) $WC = 45$, finally total transportation cost between locations has been assumed as $A = 100$.
According to formulas reported in previous section the optimal values of n and m and the corresponding lot size x^*, with a given $\theta = 0.5$ are reported in Table 1.

n	m	α	θ	x^*	TC
2	1	0.5	0.5	37.99	161.46

Table 1: Results of the model proposed with $\theta = 0.5$

Moreover we have tried to analyse the effects of different values of the percentage of renewable energy, on optimal batch size and on total costs, results are reported in Figure 2.

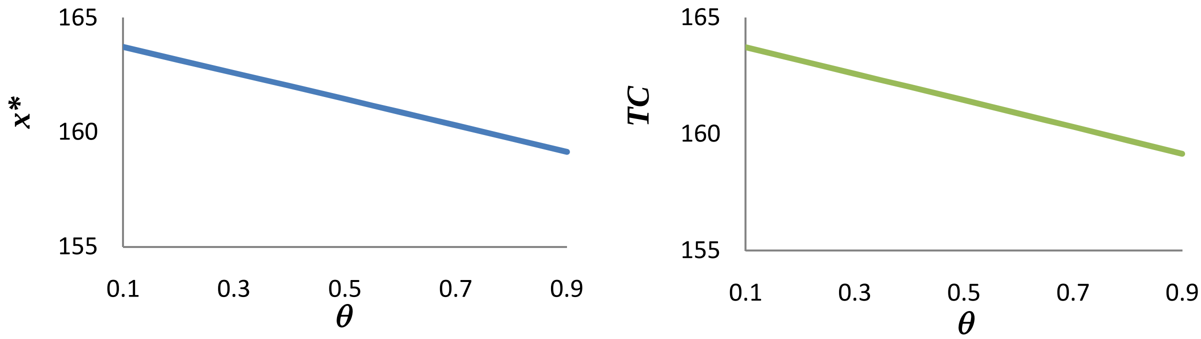


Figure 2: Optimal lot size and total cost while varying the percentage of renewable energy

According to Figure 2, while increasing the percentage of renewable energy the optimal lot size (x^*) and the corresponding total cost (TC) linearly decrease.
Moreover, so as to compare the approach proposed by Ritcher (1996), its original results are recalled in Table 2, where TC_R represents the total cost corresponding to the situation of neglecting energy costs and transportation costs (i.e. corresponding to the formula for total costs reported in Richter, 1996) and x_r is the optimal lot size according to Ritcher (1996). Moreover, in table 2 it is reported also the corresponding results of TC while considering energy, transportation and disposal costs (according to formula 1) using Ritcher (1996) decision variables results, it should be noted that we have assumed $\theta = 0.5$.

n	m	α	x_R	TC_R	TC
1	2	0.5	25.67	109.09	211.61

Table 2: Results of Ritcher (1996) and TC with energy, transportation and disposal costs with $\theta = 0.5$ (subscript R = Richter).

Thus, by following Richter's approach; i.e., without accounting for energy, transportation and disposal, the optimal policy occurs when the lot size is 25.67 units with a minimum total costs of \$109.09. While accounting for energy, transportation and disposal costs the total costs (using equation 1) increases to \$211.61.
While using the approach proposed in the paper, the optimal policy occurs when the lot size is 37.99 units, with a minimum total cost of \$161.46, suggesting a saving of 23.4% when compared to the result from Richter's model (from \$211.61 to \$161.46).
The results show that the energy, transportation and waste costs should be accounted for when optimising closed loop supply chain systems.

5. CONCLUSION AND SUMMARY.

In this paper, we have revisited the model of Ritcher (1996) by accounting for energy, transportation and waste disposal costs. Firms today have high consumption of energy and raw materials that are extracted from natural resources and heavy reliance on transportation modes that operate on non-renewable resources, which resulted in polluting the air with CO_2 emissions and soil and water tables from waste disposal activities.
Energy, transportation and waste disposal costs were not considered in earlier studies that investigated inventory models in reverse logistics context. By comparing the results to those of Ritcher (1996), it was shown that these costs significantly impact the production, remanufacturing and inventory policies. The results also showed that using a renewable or a mixed energy resource have economic and social benefits than using a non-renewable energy resource alone when considering the external costs of energy usage.
This study was conducted to provide insights needed to steer research directions in the field, and to emphasise accounting for the effects of energy, transportation and waste disposal in future studies and to be equally concerned that the models developed suggest environmentally friendly solutions. Further development to the work presented herein can consider the following enhancements:

- consider finite production rate
- consider production rate dependent transportation costs
- consider learning in production and in energy generation from renewable energy sources
- consider production/remanufacturing rate dependent energy costs

Acknowledgments
P. Hazanov thanks the Qafqaz University and Ryerson University for their support. M.Y. Jaber thanks the Social Sciences and Humanities Research Council-Environmental issues- for supporting this research. He also thanks the Ingegneria Meccanica e Industriale at Università degli Studi di Brescia for extending and financing his research visit to Brescia.

REFERENCES

1. Baetz B.W., and Neebe A.W., 1994. A planning model for the development of waste material Recycling Programmes. The Journal of Operational Research Society 45(12), 1374-1384.
2. Carlee T.R., 1986. Plastic Recycling: Economic and institutional issues. Conservation and Recycling 9(4) 335-350.
3. Dobos, I.,Richter,K.,2003.Aproduction/recycling model with stationary demand and return rates. Central European Journal of Operations Research 11 (1), 35–46.
4. Dobos, I.,Richter,K.,2004.An extended production/recycling model with stationary demand and return rates. International Journal of Production Economics 90 (3), 311–323.
5. Dobos, I.,Richter,K.,2006. A production/recycling model with quality consideration. International Journal of Production Economics 104 (2), 571–579.
6. El Saadany, A.M.A.,Jaber,M.Y.,2008.The EOQ repair and waste disposal model with switching. Computers and Industrial Engineering 55 (1), 219–233.
7. El Saadany, A.M.A., Jaber, M.Y., 2009.The production, remanufacture and waste disposal with lost sale. International Journal of Production Economics 120 (10), 115-124.
8. El-Kordy, M.N., Badr, M.A., Abed KA, Said MAI. 2002. Economical evaluation of electricity generation considering externalities. Renew Energy 25(2),317–28.
9. Khan Q.N., 2006. Alternatives to grid extension for rural electrification: Decentralized renewable energy technologies in Vietnam. Energy Policy 35(4) 2579-2589
10. Richter,K.,1996a.The EOQ and waste disposal model with variable setup numbers. European Journal of Operations Research 95 (2), 313-324.
11. Richter,K.,1996b.The extended EOQ repair and waste disposal model. International Journal of Production Economics 45 (1-3), 443-447.
12. Staikos T.R., and Rahimifard S., 2007. An end-of-life decision support tool for product recovery considerations in the footwear industry. International Journal of Computer Integrated Manufacturing 20(6), 602-615.
13. Sahin A.D., 2004. Progress and recent trends in wind energy. Progress in Energy and Combustion Science 30 (2004), 501-543.
14. Teunter,R.H.,2004.Lot-sizing for inventory systems with product recovery. Computers and Industrial Engineering 46 (3),431–441.
15. Dijkgraaf, E., Vollebergh, H.R.J., 2004. Burn or bury? A social cost comparison of final waste disposal methods. Ecological Economics 50(3-4), 233-247.
16. Jaber, M.Y., Rosen, M.A., 2008. The economic order quantity repair and waste disposal model with entropy cost. European Journal of Operational Research 188 (1), 109–120.
17. Fleischmann, M., Bloemhof-Rwaard, J. M., Dekker, R., van der Laan, E., van Nunen, J.A.E.E., van Wassenhove, L.N., 1997. Quantitative models for reverse logistics. European Journal of Operational Research 103 (1), 1–17.
18. Konstantaras,I.,Papachristos,S.,2006. Lot-sizing for a single-product recovery system with backordering. International Journal of Production Research, 44 (10), 2031–2045.

Appendix

SYSTEM	Cost factor and Life cycle cost (cent/kWh)					
	Capital cost (C)	Maintenance cost (M)	Fuel cost (F)	External cost (X)	Total cost no external (LCC-X)	Total cost with external (LCC)
CSFO	0.5969	0.1371	0.8924	3.8328	1.5928	5.4256
CSNG	0.4974	0.1271	0.7843	1.0496	1.3804	2.43
GTDO	0.751	0.5124	1.6318	2.5829	2.8434	5.4266
GTNG	0.751	0.5124	1.2918	1.5041	2.5038	4.0085
CCNG	0.5333	0.2797	0.6977	0.8749	1.4807	2.3555
PV	13.351	1.1817	0	0.1792	13.782	13.9612
WECS	1.6689	0.1865	0	0.0469	1.7616	1.8085

Table 3: Cost factor and life cycle cost for different systems (cent/kWh)

Conventional steam fuel oil fired: CSFO
Conventional steam natural gas fired: CSNG
Gas turbine diesel oil fired: GTDO
Gas turbine natural gas fired: GTNG
Combined cycle natural gas fired: CCNG
Photovoltaic: PV
Wind energy converter: WEC

ANALYZING FISHERY PRODUCTS SHIPPER'S DECISION-MAKING BEHAVIOUR

Taihcherng Lirn[1], YC Jim Wu[2], Hsuanli Chiang [3]
1. National Taiwan Ocean University
2. National Sun Yat-Sen University
3. National Kaohsiung First University of Science & Technology

ABSTRACT

Purpose:

Annual capture volume in fishery industry is estimated be over 80 million tons in 2010 worldwide and is valued at $240 billion annually. Taiwan is one of the major fishery products exporting nations and its annual export value is estimated to be $40 billion USD in 2009. The main purpose of this study is to survey and identify the key service factors and service variables influencing fishery products shippers' decision-making behaviour on finding appropriate logistics service providers (LSPs) in Taiwan. As the movement and transhipment of fishery product by cargo vessels requires a seamless transportation network, fishery products shippers in Taiwan have to take many service factors and variables into consideration, including vessel scheduling, transit duration of fishery shipment, and so forth. How to provide the best service quality to shippers in a strong competition environment is an urgent matter from local cargo carriers' and LSPs' view points.

Research approach:

This study conducts several face-to-face interviews and posts questionnaires to survey all large deep sea fishery vessel owners, midstream fishery products traders, and their products' distributors in Taiwan (the major fishery products exporters), and employs the Importance-Performance Analysis (IPA) technique to extract key service factors and service variables influencing shippers' decision-making behaviour.

Findings and Originality:

This is an original research to classify the nineteen service factors into five service dimensions for logistics service providers who want to solicit these fishery products shipments. One key service dimension (service providers' risk management ability) and top six key service factors (free time allowance, appropriate cargo claim attitude, cargo loss & damage prevention, correct documentation, clear communication with shippers, and right delivery speed) are identified to be the determinant factors which greatly influence fishery products logistics service providers overall service quality. Strategies to improve the service dimension and these six service factors are suggested. Three major strategies can be employed to improve the overall service quality provided by the fishery products logistics service providers (mainly ocean freight forwarders): (1) More C.Y. free time allowed for fishery products containers strategy, (2) Shortening cargo claim processing time strategy, and (3) Providing correct documentation by implementing a ERP system strategy.

Research impact:

This research is the first application of IPA technique on the fishery logistics industry to improve its service quality to fishery products exporters.

Practical impact:

Indicating three solid strategies to improve the fishery LSPs' service quality on their determinant factors and dimensions in the 'concentrate here' quadrant, and hopefully the

competitiveness of key fishery products LSPs can be greatly improved, and the degree of fishery product shippers' satisfaction can be increased.

Keywords: Importance-Performance Analysis, Fishery Logistics, LSP

INTRODUCTION

According to UN FAO (2003), there are three type of fisheries, including aquaculture, inland capture, and marine capture. The annual capture volume for the above-mentioned three sectors are 10^- million tonnes, 50^- million tonnes, and , 80^+ million tonnes in 2003. Dyck and Sumaila (2010) has indicated the global cross landed revenue from marine fishery (i.e. non-aquaculture, ocean fisheries) industry is estimated to be around $80 billion to $85 billion annually.

Considering the economic impacts of fisheries on other sectors, the total value of the capture fisheries industry is estimated to be about $240 billion annually. Put simply, the economic impact is three times greater. The landed value for capture fisheries is $49.9 billion and its total economic impact is $133.3 billion in the Asia. In another word, the economic impact multiplier of the capture fisheries is 2.59 in Asia. More than 55% of household income from marine fisheries is earned in Asia. China and Japan are two of the largest capture fisheries countries in Asia. China has 14.8% of global marine capture and 18.0% of global mariculture volume, and it is the largest inland capture fisheries production country in the world (UN FAO, 2003). Reported by the Fisheries Asia, China becomes the world largest fisheries products exporter by exporting $52.4 million fisheries in 2003.

The three leading fisheries products importers are Japan, USA, and Spain between 2001 and 2003. Taiwan although is not a member of UN FAO, it is yet one of the major fishery product import and export nations with about 600 thousand metric tons of export volume and 500 thousand metric tons import volume, which worth $40 billion and $30 billion respectively in 2009 (Taiwan COA, 2010).

Shipping and Fishery Products

Fish cargo ships are the major transportation vehicles for ocean going fish trawlers to offload the fishery products they harvested in the ocean without moving the fish trawlers back and forth between the fishing ground and offloading ports. Fisheries products are then sold in the fishery markets in offloading ports or being transhipped by another fish cargo ship or packed in a reefer container to be moved to their final destinations. There are three levels of distribution channel in fishery products industry (see Figure 1). Ocean going fishing vessels stationed in major fishing grounds of the three major oceans.

Caught fishery products are offloaded to fishery cargo ships, fishery cargo ships then moved their caught fishes to its home ports or any discharging ports designated by fishery cargo traders. Fishery products arrived ocean going fishing vessels' home port in Taiwan were then sorted according to their size and type before they are deep frozen to be exported abroad, these fishery products can also be distributed to fishery products processing companies or to clients' end (i.e. fish super market).

Distribution Channels and Operators of Fishery Products

Taking Taiwan as an example, there are three levels in the fishery products distribution channels, upstream level of the distribution channel is composed of many oceangoing fishing vessels owners. These owners operate both fishing vessels and fish cargo ships. They rarely use reefer containers to export their fish cargoes except in a peak seasons for fish harvest. Win Far Fishery Group (WFFG) is founded in 1978. Win Far Group owns four trawlers stationed in the Pacific Ocean, ten low temperature tuna fishing vessel stationed in the Pacific Ocean and India Ocean, and six squid and saira fishing vessels stationed in the SW Atlantic Ocean between January and July and in the North Pacific

Ocean between July and December. In addition, the group owns seven fish cargo ships, of which one ship is registered in Taiwan and the other six ships are registered abroad. More than 200,000 tons of squids and other fishes are caught by the WFFG group in the early 2000s. It might take more than a month before the fishing vessels could arrive their fishing grounds, thus fish cargo ships are employed to visit the fishery ground to offload fishery products caught by these fishing vessel. On average, it normally takes two months for a fish cargo ship to complete a round voyage service between the fishery vessels in the ocean and its offloading ports in Taiwan. Fishing vessels then can stay in the fishery grounds to continue catching fishes before the next fish cargo ships arrived.

Operators of the upstream level distribution channels usually own freezing warehouse facilities in their major discharging ports. For example, WFFG group owns four of these facilities. The operating processes for upstream operators are exhibited as Figure 2. Right after catching fishes, fishery vessels firstly put these fishes in a quick-freeze cargo hold with a very low temperature of -50 degree Celcius. When these fishes are frozen as hard as rock, they are moved to a normal freeze cargo hold with a temperature of -30 ~ -40 degree Celcius. The temperature for a normal fish cargo ship's cargo hold is about -25 degree Celcius, and a reefer container to load the fishery products are controlled at a temperature of -18 degree Celcius.

Squids caught by the WFFG are shipped back Taiwan or abroad (mainly mainland China) by fish cargo ships. If their own fish cargo vessels are not able to arrive at the fishery vessels on time, part of the fishes caught might be arranged to offloaded into local fish cargo ships to call at a neighbouring ports near fishing grounds, thus these fishery cargoes could be sold in a local consumer markets or could be transhipped by reefer containers to a final destination designated by a buyer. In 2007, WFFG did have a harvest on catching squids in the SW Atlantic Ocean and thus 9.5% of squids caught are offloaded by local fish cargo ships and fishes caught are discharged in Montevideo, Paraguay before they are packed in reefer containers to be finally moved to its home port in Taiwan.

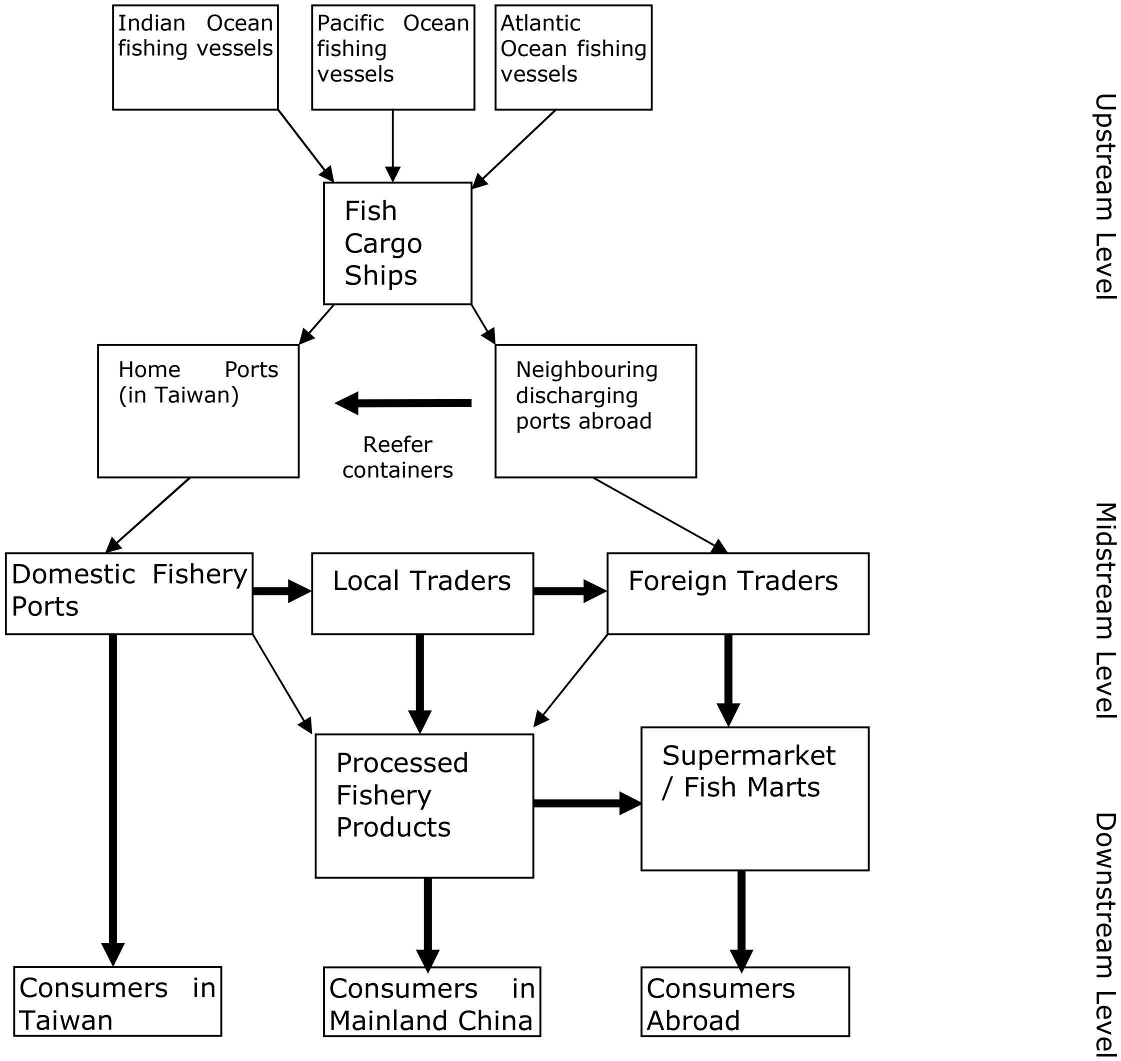


Figure 1 Three levels of distribution channel in fishery products industry

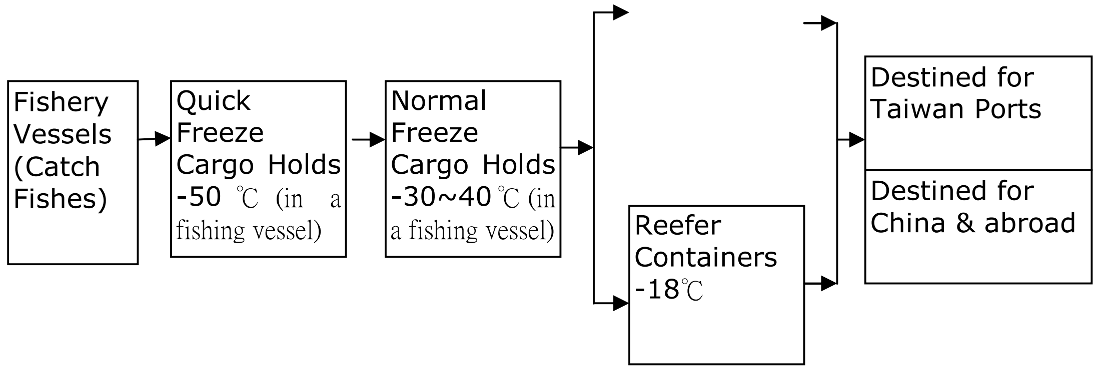


Figure 2 Operating processes of upstream fishery products distribution channel

Midstream operators of a fishery supply chain firstly imported fishery products by fish cargo ships and re-exported these cargoes by reefer containers after the operators have sorted, packed and processed these imported fishes. As midstream operators mostly used reefer containers frequently, they are the major target customers of reefer container shipping companies. Basically these midstream operators are international trading companies, and they purchased, stored, and resold the fish products abroad. FCF

Fishery Co., Ltd is the largest midstream operator who has an annual turnover of US$700 million in Taiwan. FCF provides following services, purchase and sale of various fishery products, general agencies service for foreign fishing vessels (including baits supply, fishing vessels repair and maintenance arrangement), bunker supply to fishing vessels in oceans and fish cargo reefer ships arrangement, import and export of frozen fishery products, international fishery development and cooperation arrangement, and general agent for ultra low temperature tuna export to Japan. FCF has its offices in the Pacific Ocean region (including Samoa, Tahiti, Fiji, Papua New Guinea, Micronesia, Guan, Shimizu, Philippine, Kiribati, Solomon Islands, Panama, República del Ecuador, and Peru), the Indian Ocean region (including Singapore, Penang, Bangkok, Jakarta, Seychelles, and Port Louise), and the Atlantic Ocean region (including Cape Town, Durban, Walvis Bay, Montevideo, Argentina, Falkland Islands, and Trinidad). The FCF company has three major departments: Tuna Long Liner department, Squid department, and Purse Seiner department. In the tuna long liner department, fishes caught are either handled by traditional fishing vessels with processing machineries onboard to make them into canned fishes or make them as sashimi by an ultra low temperature reefer fish cargo ships. The squid department processed mainly squids and saira. The purse seiner department purchase fishes caught by purse seiner and hep fishing vessels find fishes by helicopters. FCF company handled around 400, 000 tons fishes annually, most of its fish cargoes are processed by outsourcing these manufacturing activities to a third party seafood processing factories. Fishery cargo flow of FCF Company is exhibited as Figure 3.

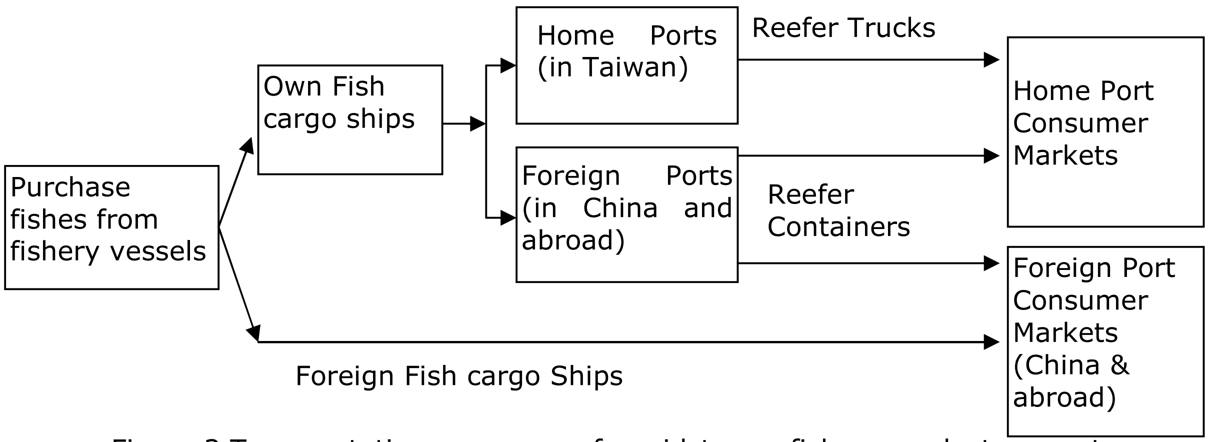


Figure 3 Transportation processes of a midstream fishery products operator

Downstream fishery products operators purchase fishes from upstream operators and midstream operators. Fishes from marine capture and aquaculture are sorted, packed, processed, frozen, stored, wholesaled, and retailed. Fish could be processed into moist-type products and dry-type products, including frozen, canned, dried and salted, seasoned kamoboko, fish noodles, surimi products, fish nuggets, fish balls, dry seaweed, fabricated fish steak, and fish meat sausage. Shin Ho Sing Ocean Enterprise Co., Ltd is founded in 1966 and is one of the largest downstream fishery products operators in Taiwan.

This company is well known for its dried shredded squids. It also sells fish finger, fish stead, seaweed jam, frozen tuna, seasoned squid, shrimp nuggets, cuttlefish dumpling, and fly fish roe in bottles. Its moist-type products are mainly exported in reefer containers.

Purpose of the research
Fishery products are one of the major foreign reserve contributors in Taiwan, and it generates $5.94 billion USD and $1.98 billion USD trade surpluses in 2000 and 2007.

Taiwan is an island economics. Its fishery industry can be flourished only if the whole fishery products distribution channels are well managed. However, according to the authors' knowledge, previous researches on the fishery logistics in Taiwan are simply not found. Maritime transportation service is one of the major segments in a fishery products distribution channel. Thus this research intends to find out the degree of importance of LSP's (mainly ocean freight forwarders') service attributes influencing fishery products shippers' shipping mode selection behaviour in Taiwan.

Literatures Review

Researches on shippers' selecting carrier behaviour can be found as early as in 1980s. Brooks (1985) surveyed American shippers using ocean container shipping services, and found fifteen factors have major influence on shippers to select carriers, including freight rate, carriers' reputation, and service frequency, etc. Matear & Gray (1993) indicate ten factors are important to influence shippers' selecting their ocean freight service providers, including freight rate, service frequency, and service speed.

In a study on shipper's expectation, Gooley (1994) indicates high service quality, fast service speed, punctuality, traceability, and correct documentation are the top five expected service attributes that shippers needed. Murphy and Daley (1997) investigate 375 members of the Council of Logistics Management and found there are twelve important service attributes when shippers choose their international freight forwarding service providers, including professional expertise, service reliability, and informatics ability. Kent and Parker (1999) investigated carriers on their carriers' selection behaviour and found punctuality, freight rate, and degree of freight discount are the top three important criteria out of the eighteen service attributes they had reviewed.

A study of Lu(2003) shows that shippers have considered thirty service attributes when they choose ocean carriers as their partners, including availability of cargo space, and cargo damage and loss prevention.

The work of Yen and Chen (2004) shows there are six dimensions with 22 service attribute influence shippers' ocean carriers selection behaviour, namely, reputation and service attitude, carriers hardware condition and convenience to deliver and pickup their freight assignments, minimum batch size of the cargo shipped, number of ports of call and direct service, good cargo damage and loss record with good EDI system, and availability of spaces and punctual service schedule.

To conclude service attributes influencing shippers' selecting ocean transportation service providers behaviour reported in the abovementioned researches, fifty two service attributes are sorted into 19 factors by the authors as shown in Table 1. These 19 dimensions are further clustered into five a group of dimensions as exhibited in figure 4.

Table 1 Important service attributes perceived by shippers

Factors	Service Attributes / Authors	Brooks (1985)	Matear & Gray (1993)	Gooley (1994)	Murphy & Daley (1997)	Kent & Parker (1999)	Lu (2003)	Yen & Chen (2004)
1.Freight rate	1.1 Freight Discount					※	※	
	1.2 Freight Rate	※	※		※	※		
2.Availability of cargo space	2.1 Availability of cargo space						※	
	2.2 Carriers' service capacity	※	※					
	2.3 Size of carriers				※			
3.Direct link service	3.1 Direct link service	※				※		※
	3.2 Number of ports of call	※						※
4.Service Frequency	4 Service Frequency	※	※			※	※	※
5.Service Flexibility	5 Carriers' service flexibility (e.g releasing cargo without B/L)	※	※			※		
6.Delivery speed & punctuality	6.1 Delivery speed					※		
	6.2 On time pick up cargoes						※	
	6.3 Punctual schedule	※	※	※		※	※	※
	6.4 Steaming speed of ship	※	※	※		※	※	
7.Correct documentation	7 Correct documentation		※	※			※	※
8.Ease of shipping procedure	8.1 Appropriate office location				※			
	8.2 Availability of long term service contract	※						
	8.3 Convenience of shipping procedure				※			※
	8.4 Diversified value-added services				※			
	8.5 door-to-door service					※		
	8.6 Inland transport service						※	
	8.7 Packaging & labeling service						※	
	8.8 Warehousing service						※	
9.Cargo traceability	9 Cargo traceability					※		
10.Equipments condition	10.1 Condition of cargo containers						※	
	10.2 Condition of equipments					※		
	10.3 Provision of special cargo handling equipments					※	※	※
11.Marketing ability & advertisement	11.1 Carriers marketing ability					※		
	11.2 Providing service schedule in newspaper & magazine						※	
	11.3 Reliability of carriers' advertisement	※						
12.Reputation & corporate image	12.1 Carriers reputation	※			※	※		※
	12.2 High service quality			※				
13.Financial stability	13 Financial stability				※	※		
14.Cargo loss & damage record	14.1 Cargo loss & damage record	※	※				※	※
	14.2 Degree of cargo damage					※		
15.Professional expertise	15 Professional expertise				※	※	※	
16.Clear communication with shippers	16.1 Fitness between carriers & shippers	※	※					※
	16.2 Salesman service attitude	※			※	※	※	
17.Quick response to customers demai	17 Process speed on cargo claim					※		
18.EDI processing ability	18 Informatics ability			※	※		※	※
19.Appropriate service attitude	19 Attitudes towards shippers' complain & claim	※				※		

Source: this research.

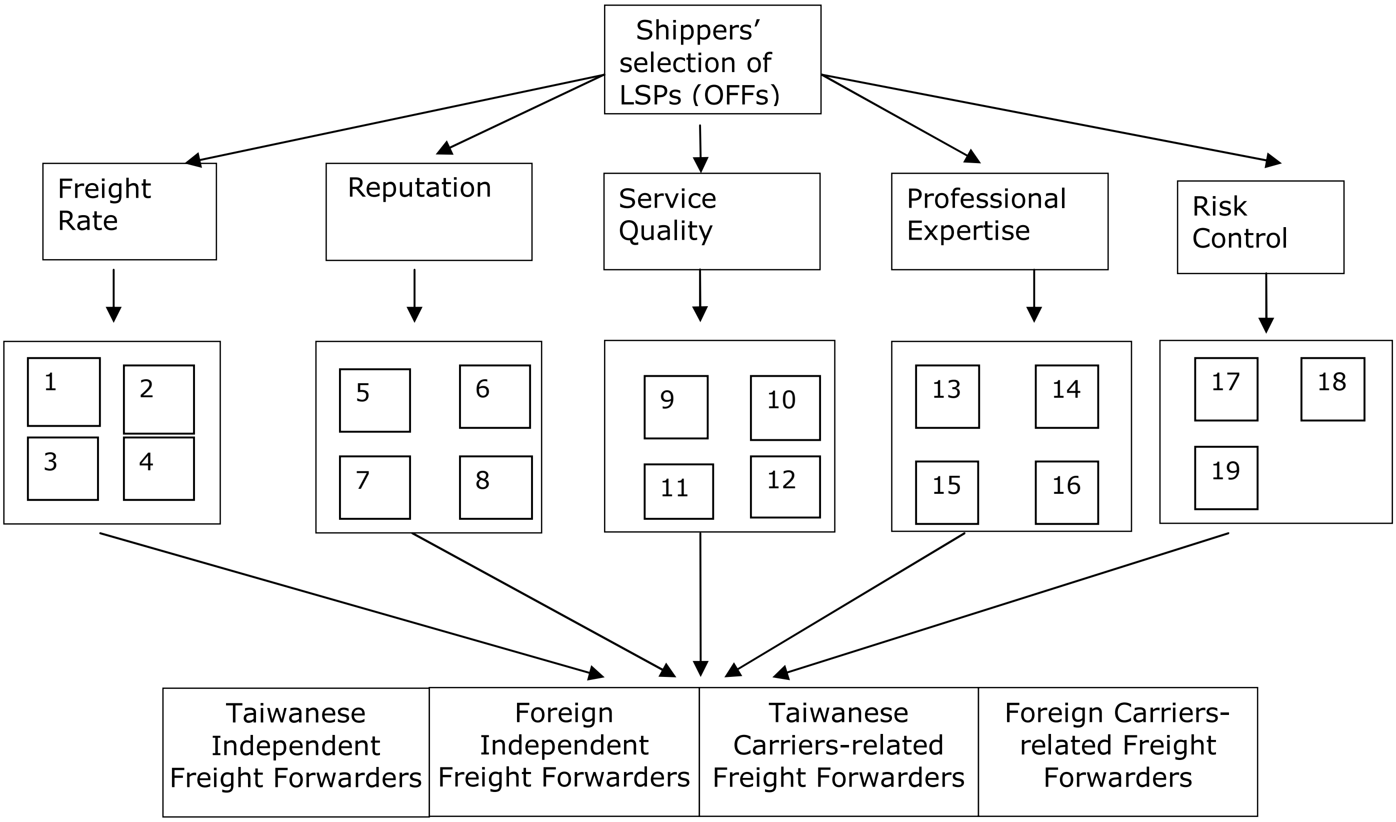


Figure 4 Hierarchical Structure of Shippers Decision-making Process

(1) Freight rate: 1.Service frequency, 2.service speed, 3.direct link service, and 4.free time allowance.
(2) Reputation: 5.Marketing ability & advertisement, 6.reputation & corporate image, 7. financial stability, and 8.cargo loss & damage record.
(3) Service quality: 9. service flexibility (B/L release speed), 10. punctual delivery, 11. correct documentation, 12. ease of shipping procedure.
(4) Expertise: 13. professional expertise, 14. clear communication with shippers, 15.quick response to customers demands, 16. EDI processing ability.
(5) Risk Control: 17. Equipments' condition, 18. cargo traceability, and 19. appropriate cargo claim attitude.

Research Methodology

Importance-performance analysis (IPA) is firstly proposed by Martilla & James in 1977. IPA is using a matrix to exhibit the importance and performance for a group of service attributes in a two dimensional space. The vertical axis and horizontal axis can be swapped, and the quadrants and the scale of the matrix can be assigned subjectively. The key issue in using IPA is to find out the relative position of service attributes in the matrix. Sampson & Showalter (1999) indicated IPA is a technique to rank the priority of various service attributes by measuring a service attribute's importance and a service provider's performance on the service attribute perceived by consumers. They proposed three prerequisites to employ the IPA technique, (1) There must be a relationship between importance and performance, (2) Usually, the perceived importance and perceived performance of a service attribute has a negative correlation. In another word, if customers perceived the service providers have already performed very well in a service attribute, then the importance of this service attribute will be greatly decreased, (3) Importance is a dependent variable of performance. Put simply, a change on the degree of performance of a service attribute will result in the change of the degree of importance of that service attribute. O'Sullivan (1991) suggested there are four steps in employing the IPA technique, (1) listing all possible service attributes involved in a research topic and develop a Likert scale questionnaire accordingly, (2) inviting users of the same service providers to evaluate the importance and performance on various service attributes provided by the same service providers, (3)using importance of service attributes as vertical axis and the performance of service attributes as horizontal axis, positioned all service attributes in a two-dimensional space (i.e. in a matrix), (4) employing median values of performance and importance on all service attributes as their origin points' coordinates to construct a matrix of four quadrants as shown in figure 5.

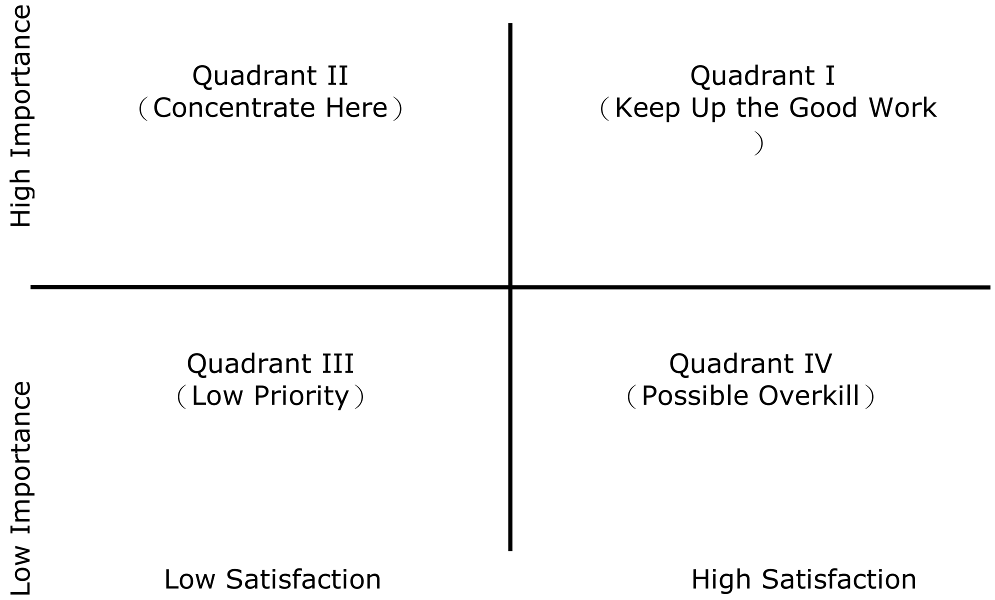


Figure 5 Importance-performance analysis (Source: Martilla & James, 1977)

Quadrant I: Keep up the good work – it implies customers perceive a service attribute is important and are satisfied with service providers' performance on this service attribute. Thus service providers should keep up the good work.

Quadrant II: Concentrate here – customers perceive a service attribute is very important and their service providers has a below average performance on this service attribute. Service providers should strengthen their performance on this attribute.

Quadrant III: Low priorities – customers are not satisfied with the performance of their service providers on low important service attributes. This might be result from low input or no input from service providers on these service attributes.

Quadrant IV: Possible overkill – Customers perceive a service attribute has a low degree of importance and a high degree of performance. These service attributes do not make a great contribution to increase customers' overall degree of satisfaction. Service providers spend too many resources on this service attribute, and they should avoid spending extra resources to improve the performance on this service attribute. Instead, if a provider's resource is limited, it should consider retreat its inputs in these service attributes.

Sampling

This research firstly interviewed managers in the midstream and downstream of fishery products distributors in Taiwan to understand their criteria on selecting ocean freight service providers, then these criteria are used to design five point Likert scale questionnaires. Questionnaires are then distributed to fishery product shippers to survey how they choose their reefer shipping service providers with an importance-performance-analysis matrix. There are 82 companies with their full memberships and 40 companies with their associate membership in the Taiwan Fishery Products Association (TFPA).

Telephone contacts were firstly carried out to know if they ever had used reefer containers service to export their products and their willingness to respond this survey. Companies have not used reefer container service for export is excluded from this survey. Thirty five copies of questionnaires were finally sent to thirty two members of the TFPA association have promised to reply this survey. Three quarters of surveyees have responded this survey and twenty seven copies of completed questionnaires were received. Respondents' profile is shown in Table 2. The credibility of this research findings are hence greatly increased with this high response rate.

Table 2 Respondents' Profile

Demographic Variables	Category	Number of Respondents	Percentage
Company History	0 ~10 years	4	10%
	11~20 years	6	10%
	21~30 years	2	20%
	31~40 years	12	50%
	41 years & above	3	10%
Seniority on current job position	Under 1 years	1	4%
	1~3 years	5	15%
	4~5 years	4	19%
	6 years & above	17	62%
Number of employees in the company	Under 30	11	41%
	31~ 50 persons	1	4%
	51 ~100 persons	6	22%
	101~300 persons	9	33%
Position	Managers	3	11%
	Trading executives	12	44%
	Shipping staffs	5	19%
	Assistant Sales	7	26%
Annual revenue	Below $1 million USD	4	15%
	$1 ~7 million USD	11	41%
	Above $7 million USD	12	44%

Source: this research

Research Findings and Implications to Industry and Academic Theory

Exhibition on the importance and performance between the five service dimensions are shown as figure 6. The median value for the service importance is 3.48 in the X-axis and the median value for the performance is 4.07 in the Y-axis, the origin point of the figure is intersected at these two median values. Ocean freight forwarders (OFFs) providing reefer container service are perceived by their fishery product shippers to have a low degree of importance with a low degree of performance on 'freight rate dimension'. From OFFs' viewpoint, as one of the most major logistics service providers to fishery product exporters, the OFFs could sign a service contract with ship owners and has a high degree of loyalty to a single ship owner. Thus an OFF might be able to obtain a discounted freight from a ship owner to lower its quoted freight to fishery products exporters. From shippers' perspective, shippers might want to focus on their core competency in doing fishery trade and are willing to spend premium freight rate to let their OFFs solve non-competency related logistics issues. Therefore some OFFs do provide total solution service and door-to-door service to their shippers.

Shippers perceive 'reputation service dimension' has an average degree of importance and low degree of performance. There are more than 500 OFFs registered in the international Ocean Freight Forwards and Logistics Association Taiwan. Most OFFs simply have their advertisement on professional shipping newspaper, and their reputation is mostly built upon their diligent sales calls and upon references by their cooperated custom house brokers. Thus shippers will decide the reputation of an OFF by the appearance of OFFs' salespersons and OFFs' historical performance record. In the 'service quality' dimension and the 'professional expertise' dimension, the shippers have perceived these two dimensions have an above-average degree of importance and OFFs has a good performance on these two dimensions. The OFFs should keep up the good performance on these two dimensions. 'Risk control' dimension is situated in the 'concentrate here quadrant' which indicates shippers perceive this dimension is a critical service dimension. Three service factors are included in the 'Risk control' dimension, namely, 'reefer containers' condition', 'cargo traceability', and 'appropriate cargo claim attitude'. Improvement of OFFs' performance on these three service attributes is required.

Detailed analyses on all 19 factors in the 5 dimensions are exhibited from Figure 6 to Figure 11. Authors find there are six factors located in the 'concentrate here' quadrant in the Figure 7, 8, 9, 10 and 11. These six factors are 'free time allowance', 'delivery speed and punctuality', 'cargo loss & damage prevention', 'correct documentation', 'clear communication with shippers', and 'appropriate cargo claim process'.

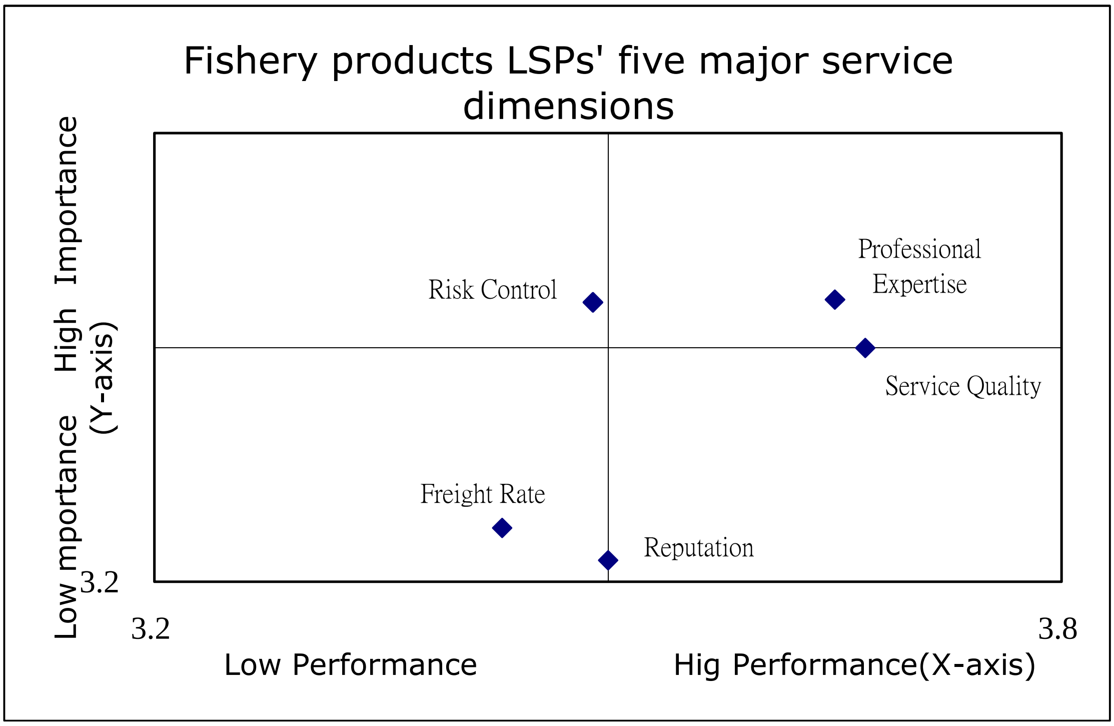


Figure 6 IPA of Fishery products LSPs' five major service dimensions

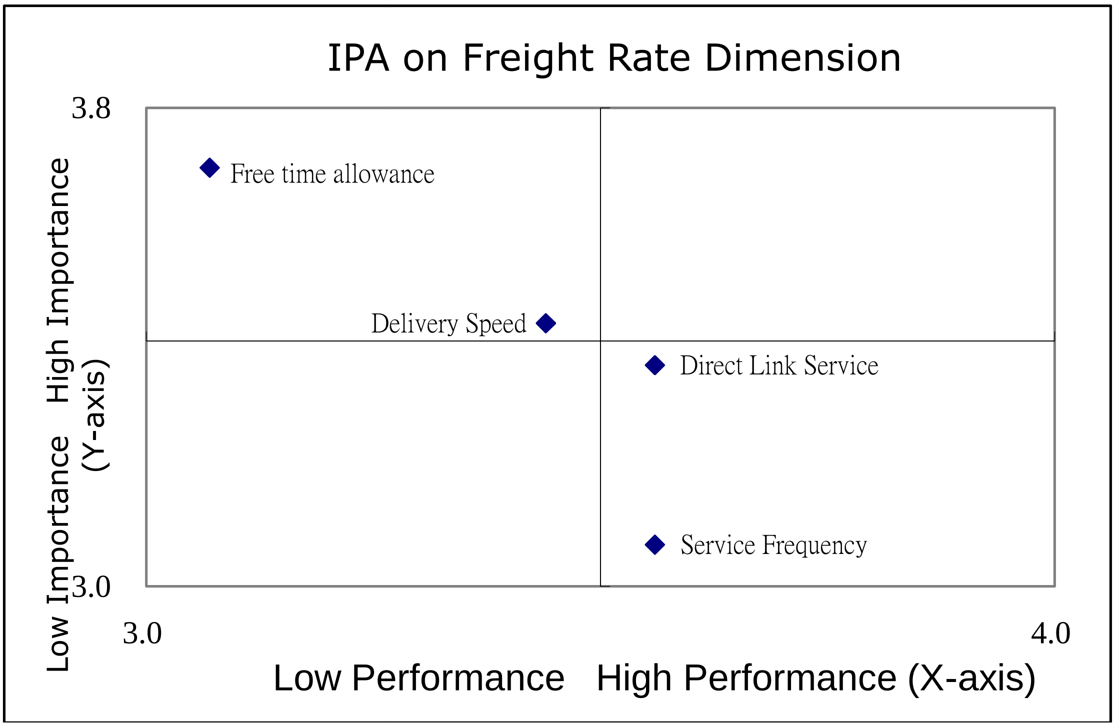


Figure 7 IPA on Freight Rate Dimension

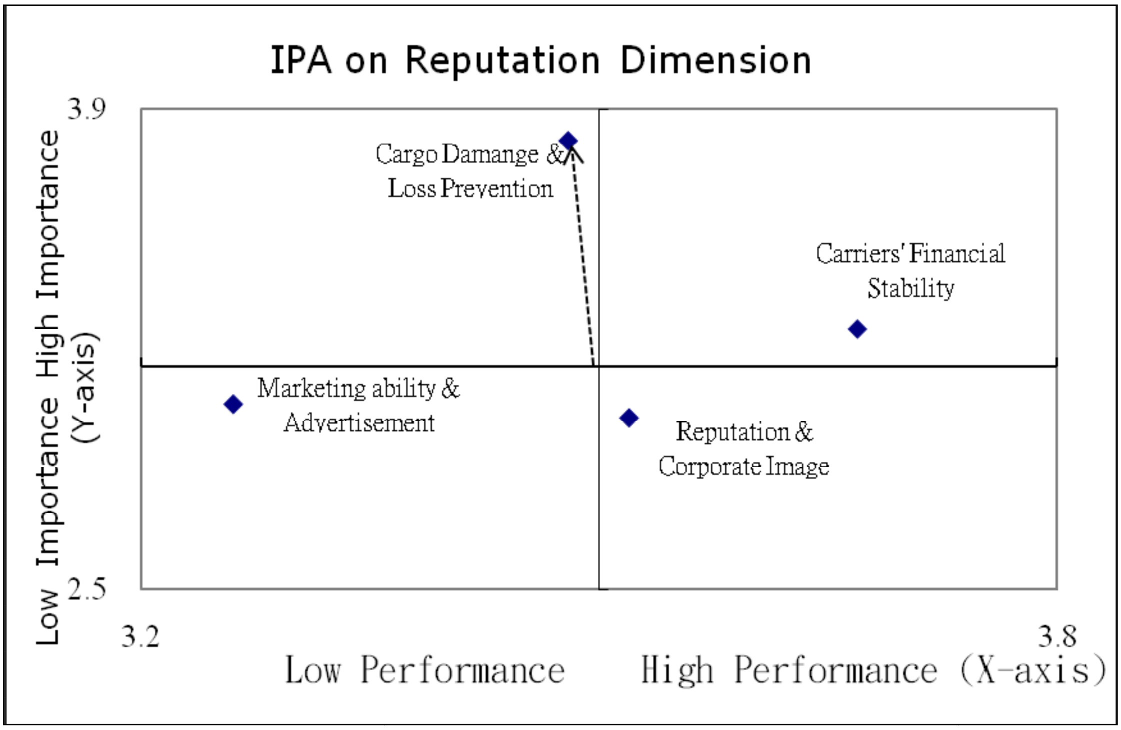


Figure 8 IPA on Reputation Dimension

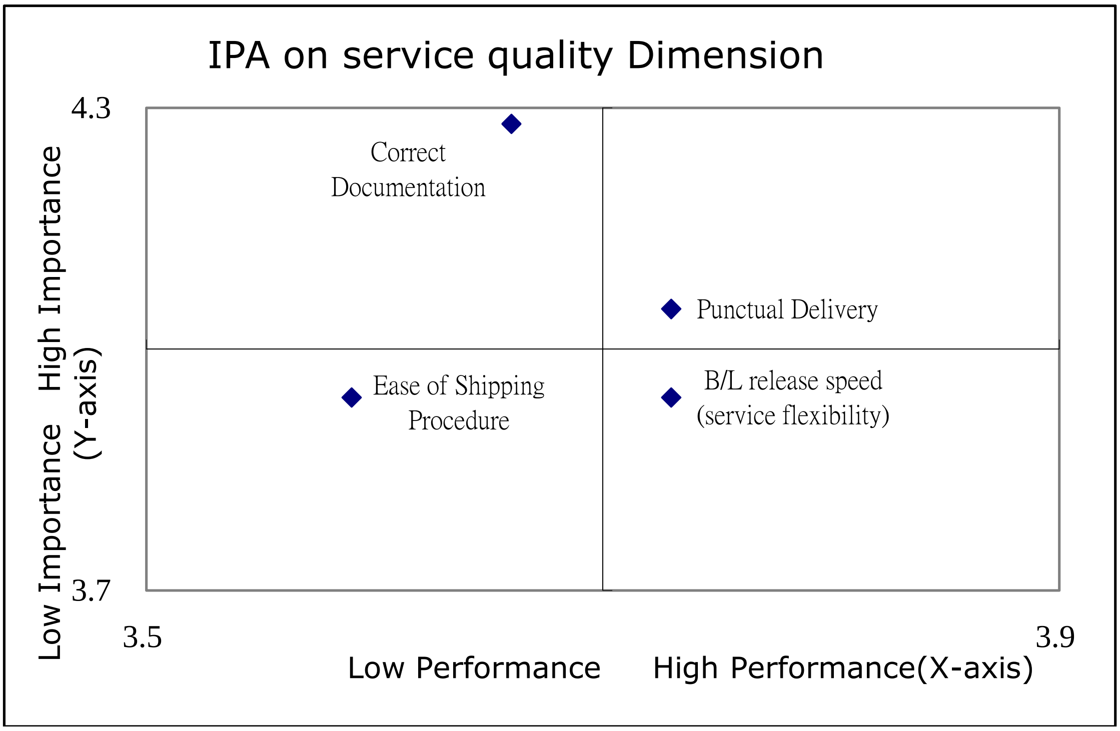


Figure 9 IPA on Service Quality Dimension

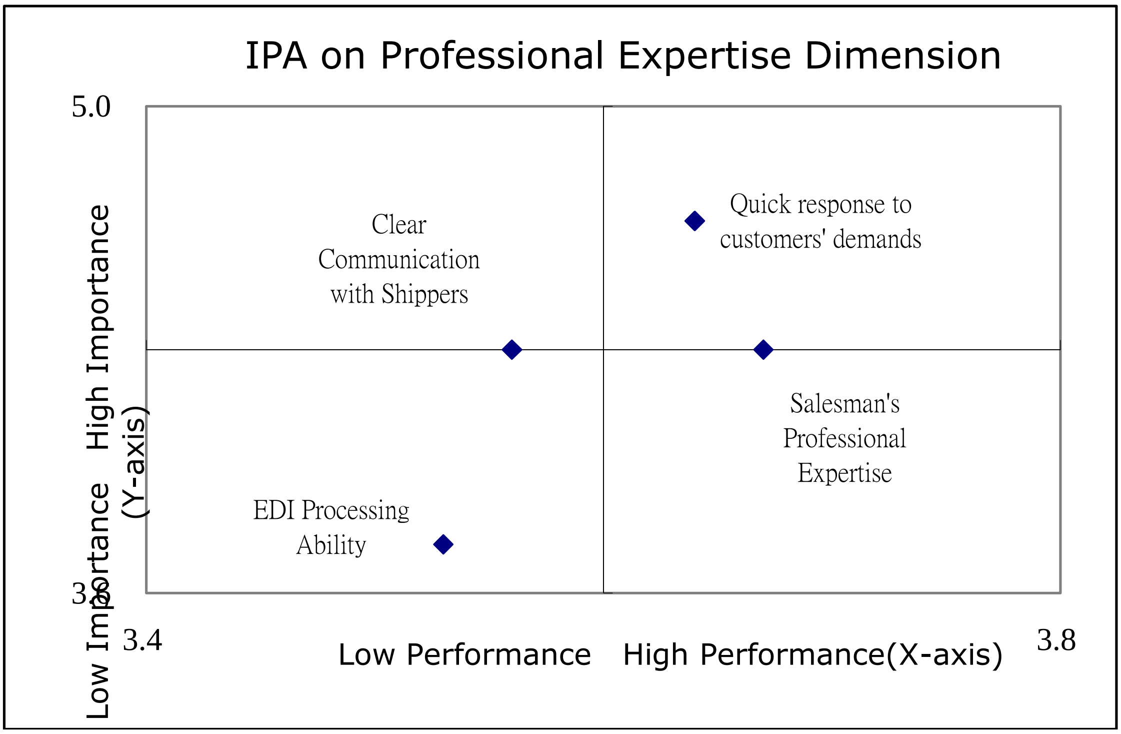


Figure 10 IPA on Freight Rate Dimension

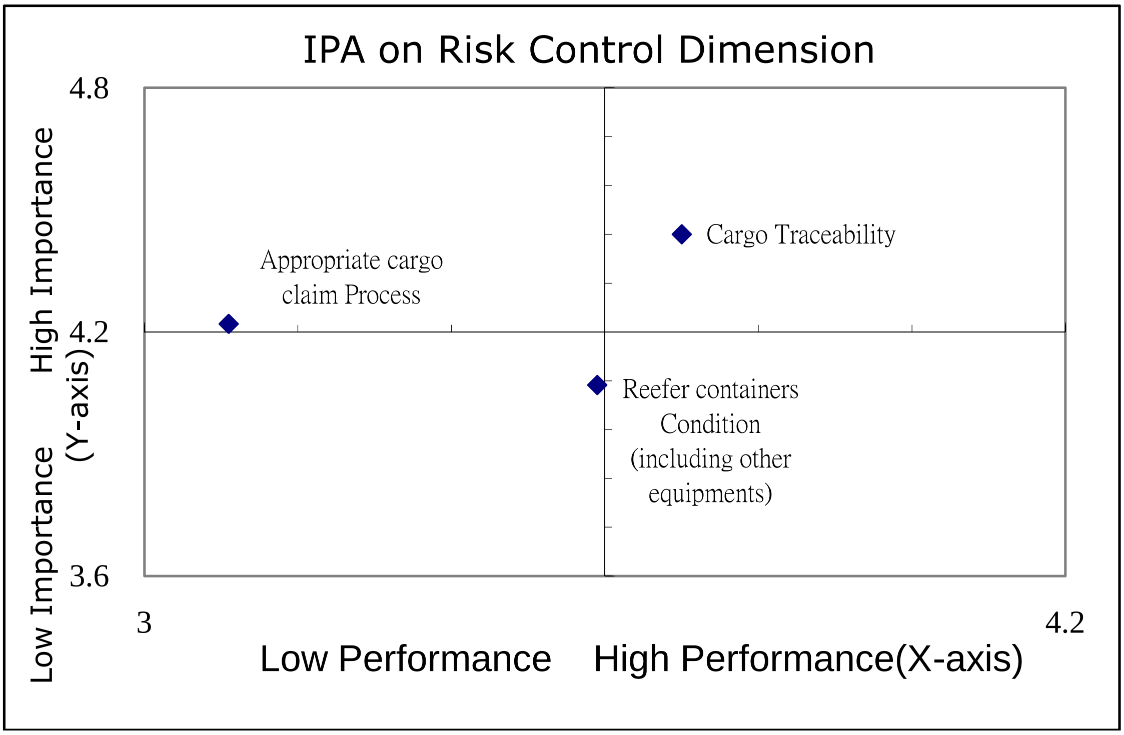


Figure 11 IPA on Risk Control Dimension

Discussions

There are two types of 'free time': demurrage free time and detention free time. Demurrage is concerning the free time allowance for loaded containers to be stored in the container yards without extra storage charge. Detention is the free time allowance for empty containers to be used by the shippers to load their cargoes outside container yards. Free detention time and free demurrage time awarded to shippers might be different between nations and between import containers and export containers. To release port congestion problems in a peak season, port authorities usually encourage carriers to decrease their 'free time' offer to shippers and consignees. Consignees in India usually expect carriers offer a minimum 14 days 'free time' for the reefer containers they used, while carriers in Hong Kong and Taiwan only offer 3~5 days free time to local consignees in these two regions. However, large shippers using reefer containers shipping services usually negotiate with OFFs to extend the 'free time' to be greater than 3~5 days in Hong Kong and Taiwan. 'Punctual delivery' factor is important to shippers because various fishery products have to meet their local retailers' promotion activities and OFFs should manage to improve their performance on this service factor.

OFFs usually do not highly emphasize their service attributes on 'cargo loss & damage prevention' factor. From shippers' viewpoint, responsible OFFs should always make shippers be confident on the safety arrival of their freight consignment. OFF office staffs' performance on correctly typing documents should be improved to meet different shippers' requirements. Low performance on 'clear communication with shippers' factor is required because of various regulations on fishery products in different discharging ports. It requires a clear communication between shippers and OFFs to make the fishery products move smoothly in a logistics pipeline. 'Appropriate cargo claim process' factor is always a major issue to OFFs, shippers cannot find their freight consignment damaged until reefers containers arrived their consignees warehouse. There are at least two possible causes resulting in frozen fishery products damaged: abnormal reefer temperature control during ocean voyage and during container yards in departure ports and destination ports. OFFs should well communicate with shippers to know whether any loading requirement has to be followed before fishery products are loaded in a reefer container for export. If cargoes are found damaged, photos should be firstly taken and cargo loss surveyors should be notified.

CONCLUSIONS AND SUGGESTIONS

In this study, 'risk control' is the only one out of the five dimensions situated in the 'concentrate here' quadrant. Of the three factors in the IPA on 'risk control' dimension (see figure 11), 'appropriate cargo claim process' is perceived to be situated in the 'concentrate here' quadrant. If a freight consignment is shipped smoothly, then all logistics service providers' (mainly OFFs in this study) performance on the other 18 service factors are not greatly differed. As a Chinese proverb goes, 'A rider can see a potential of a horse only by a long distance travelling with it. One can find a person's real friendship being in a trouble era with him'. 'Cargo claim' is an infrequently occurred event during LSP's daily operations. However, most fishery shippers perceived the 'appropriate cargo claim service process' factor to be very important. Only OFFs with an appropriate degree of performance on this service factor can be perceived trustful by their fishery shippers. An untrustful OFF is not likely to win their shippers' continuous loyalty. Using a measurement on the distance between the coordinates of origin and the coordinates of service factors in the 'concentrate here' quadrant in figure 7 ~ figure 11, the longer the distance between these two points, the more resources should be invested to improve these service factor. Suppose the coordinate of origin point of a geometric surface is (X_1, Y_1) and the coordinate of a service factor is (X_2, Y_2), then the distance between these to points can be found by the formula: d = $\sqrt[2]{(X_2^2 - X_1^2) + (Y_2^2 - Y_1^2)}$. Using this formula, authors find the 'free time allowance' factor has the longest distance from its origins point in figure 7, following by 'appropriate cargo claim process', 'cargo loss & damage prevention', 'correct documentation', 'clear communication with shippers', and ''delivery speed' factors. Thus priority to invest resources on these 'concentrate here' factors is ranked accordingly. Measurement on the performance of different types of freight forwarders exhibited in figure 4 can be carried out in the future research. Thus, more fruitful findings and detailed suggestions to different type of freight forwarders can be concluded for these freight forwarders and other fishery logistics service providers.

REFERENCES

Brooks, M. R.(1985).An alternative theoretical approach to the evaluation of liner shipping -part II: Choice criteria. Maritime Policy and Management, 12(2), 145-155.

Dyck, A.J. and Sumaila U.R.(2010) Economic impact of ocean fish populations in the global fishery. Journal of Bioeconomics. DOI: 10.1007/s10818-010-9088-3

Gooley, T.B.(1994) How to Choose an Ocean Carrier, Traffic Management,31,.83A.

Murphy, P. R., & Daley, J. M.(1997) Investigating selection criteria for international freight forwarders. Transportation Journal, 37(1), 29-36.

Kent, J. L., & Parker, R. S.(1999) International containership carrier selection criteria shippers/carrier differences. International Journal of Physical Distribution & Logistics Management, 29(6), 398-408.

Lu, C. S. (2003). The impact of carrier service attributes on shipper-carrier partnering relationships: A shipper's perspective. Transportation Research Part E, 39(5), 399- 415.

Martilla, J. A., & James, J. C. (1977). Importance-performance analysis. Journal of Marketing, 41(1), 77-79.

Matear, S., & Gray, R. (1993). Factors influencing freight service choice for shippers and freight suppliers. International Journal of Physical Distribution &Logistics Management, 23(2), 25-35.

O'Sullivan, R. L. (1991). Marketing for parks, recreation, and leisure, State College, PA: Venture.

Sampson, S. E. & Showalter, M. J.(1999), The performance-importance response function: Observations and Implications, The Service Industries Journal, 19(3), 1-25.

Taiwan COA (Council of Agriculture) (2009) Fisheries Statistical Yearbook
Taiwan, Kinmen and Matsu Area, 2009.

UN FAO (2003) Review of the State of World Fishery Resources: Inland Fisheries. Rome, Italy: United Nation, Food and Agriculture Organization.

Yen C.J. & Chen S.M (2004) Modelling the Shippers' Behaviour in Short-Sea Routes, Maritime Quarterly, 13(2), pp.73~ 96.

Web Resources: Fisheries Asia (undated) Status Of World Fisheries Development, accessed http://www.fisheries.asia/a1068934-status-of-world-fisheries-development.cfm on 17/04/2011.

(RE-)POSITIONING OF LOGISTICS SERVICE PROVIDERS IN A GLOBALISED WORLD – AN EMPIRICAL SURVEY ON POSITIONING MODELS AND STRATEGIC CAPABILITIES

Michael Hülsmann[1], Benjamin Korsmeier[2], Verena Brenner[3], Jacobs University gGmbH
Josef Decker[4], Michael Krähe[5],
Hochschule für Internationale Wirtschaft und Logistik
1m.huelsmann@jacobs-university.de, 2b.korsmeier@jacobs-university.de,
3v.brenner@jacobs-university.de, [4]decker@bvl.de, [5]kraehe@bvl.de

Acknowledgement
This research was supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations".

INTRODUCTION

Logistics Service Providers (LSP) have to face the strategic challenges of a relatively homogenous product span: Transporting, storing and handling goods is not determined by a versatile and volatile spectrum of product-related characteristics (Davis, Golicic & Marquardt 2008). Hence, LSP can deploy only limited opportunities to position and differentiate their services and companies; achieving a competitive position in distribution logistics service markets seems to be majorly restricted to price, place and promotion as key components of the marketing mix (Speh 2008). Moreover, diverging and changing customer expectations from all over the world (Narasimhan & Das 1999), developing and challenging market activities of international competitors (Dornier et al. 1998), ubiquitous and real-time information accessibility (Siegele 2002), fluid and diffuse market structures, global and standardised service supply, etc. force the LSP to adapt their strategies constantly and very flexibly (Hülsmann, Grapp & Li 2008, Person & Virum 2001). Hence, a LSP has to redefine its strategic agenda and to re-position itself in the markets (Lemoine & Dagnaes 2003). In order to learn more about the strategic implications and constraints of a globalised world for LSP this paper intends to provide first exploratory insights into the positioning of German LSP in the field of distribution logistics.

The paper – besides introduction and conclusions – will firstly provide a comprehensive overview about positioning and positioning models for LSP; secondly, it intends to give an overview about the current positioning and the underlying resources of LSP in the German market. Thirdly, the paper would like to outline a framework for prospective needs and possibilities for the repositioning of German LSP.

POSITIONING MODELS FOR LSP

Logistics companies act in volatile markets as well as environments. Additionally, forecasts expect growing environmental uncertainty with every passing year (Wheelen 2006). That results from the fact, that companies are confronted with permanent changes in their close environment (e.g. changing customer demands on their local markets) as well as in their broader environment (e.g. exchange rate shifts or interest rates) (Saloner, Shepard & Podolny 2001). Thus, companies have to find a successful, sustainable and adequate strategic position in order to cope with these environmental challenges. However, aiming only for the right position to customers (deliver highest customer value) and competitors (try to differentiate) (Bruhn 2009) does not guarantee success, since rivals can copy a market position very easy and competitive advantages are mostly temporary (Porter 1996). Thus, companies have to be flexible. That means they have to adapt their own strategic behaviour or rather their own position according to changing customer requirements and competitors positions. This ability to establish and adapt a certain position in the market is based on a company's resources and its capabilities, since a certain position requires resources (assets owned by a company), which can lead to capabilities (what a company can do) through an appropriate resource allocation (Grant 2005). In result, companies can gain long lasting competitive advantages based on their unique capabilities and resources, which are difficult to imitate by competitors (Johnson & Scholes 2008) and which have to be changeable (e.g.

adaption of human skills in order to meet changing customer demand for new products or services).

Regarding the repositioning two different options are possible: A customer oriented repositioning in order to meet the position demanded by the customer on the one hand or on the other hand a competitor oriented repositioning which aims for a position which is as far as possible away from those of competitors (Trommsdorf & Paulssen 1999). Regarding the positioning of LSP the literature provides different analysis approaches. According to Juga et al., positioning models for LSP can be distinguished regarding the model type (classical positioning models, resource/ competence based models), the model dimensions (characteristics) and the offered position classification. Thereby, resource and competence-based models aims for displaying the position base on the LSP assets (resources) and capabilities (Juga, Pekkarinen & Kilpala 2008). Examples for classical positioning models are given by (Delaney 1991), (Cooper, Browne & Peters 1994), (Bask 1999), and (Person & Virum 2001). Resource and competence-based models are introduced beside others by (Africk & Calkins 1994), (Berglund 1999), (Schary & Skjott-Larsen 2001), (Bask 2001), and (Hertz & Alfredsson 2003). Regarding the model dimensions the classic positioning models basically refer to the broadness of service portfolio and the industry presence, whereas the resource and competence based model refer e.g. to asset specify, complexity of services, degree of customer integration or offered physical services vs. management services. For displaying the current positioning of LSP in Germany a resource and competence-based model will be used, since the importance of resources and competences (capabilities) for the positioning was already reasoned above. The resource and competence based model, which originates from the research of (Hertz & Alfredsson 2003) and bases on the research of (Hakansson & Johanson 1982), compares the dimensions "general ability of problem solving" (high/ low) and "ability of customer adaption" (high/ low). The model classifies the LSP in terms of Standard Transport Firms, Traditional House Brokers or Warehousing Firms, Integrators, and TPL Providers. The TPL Providers are further classified into Standard TPL Provider, Customer Adapter, Service Developer, and Customer Developer. Moreover, a TPL Provider is defined as an "external provider who manages, controls, and delivers logistics activities on behalf of a shipper" (Hertz & Alfredsson 2003).

POSITIONING, RESOURCES AND CAPABILITIES OF LSP IN GERMANY

For displaying the current positioning of LSP in Germany an empirical study was arranged with ten logistics experts. The expert interview form was used because of the importance of the individual expert knowledge for the exploratory survey (Bortz & Döring 2006). Moreover, the advantage of the personal interview form towards e.g. a web-based interview form lies in the possibility to obtain complete and precise information during the face-to-face interview situation (Zikmund 2003). The logistics experts are located in different business areas (production logistics, distribution logistics, consultancy, logistics education). That should assure a broad and comprehensive view on the logistics industry. For the evaluation a verbalised four item scale was used in order to avoid indecisive answers, which are located in the middle of the scale (Porst 2008). During the interviews the logistics experts were asked regarding their estimation of the LSP "general ability of problem solving" and the "ability of customer adaption" as two examples for logistics provider's capabilities. The capabilities were evaluated regarding their general importance (not important, less important, important, very important) for LSP and the estimated configuration (very low, low, high, very high). The experts' answers can be summarised as follows:

90% of the experts estimate the importance of the general ability of problem solving for LSP as very important (50%), or important (40%), and one expert as less important (10%). Regarding the configuration with the general ability of problem solving all experts estimate the configuration for LSP in Germany as high (100%). The ability of customer adaption is mostly rated as important (60%). Two experts rate it as very important (20%) and two as less important (20%). The ability of customer adaption is estimated as high (50%), low (40%), or very low (10%) in terms of the LSP configuration.

The results clearly show a gap between the importance of the evaluated abilities and the estimated configuration. Regarding the ability of problem solving half of the interviewed experts rate it as very important, whereas four experts rate this ability as important and one expert as less important. That shows a core in the "very important" area. However, the configuration is rated as "high" by all interviewed experts. Thus, a gap between the importance (very important) and the configuration (high) can be assumed. It becomes more obvious regarding the ability of customer adaption: 80% percent of the experts rate this ability as important or very important and 20% as less important. However, 40% evaluate the configuration as low, 50% as high, and 10% as very low. Thus a gap can also be assumed regarding the ability of customer adaption cause of the rated importance (important and very important) and the rated configuration (high and low). Thus, it can be assumed that because of the identified gap between the importance of the abilities and its configuration an adaption of the abilities or rather a repositioning is required through an appropriate resource adaption. Therefore, the positioning is displayed in the following figure based on the configuration estimation:

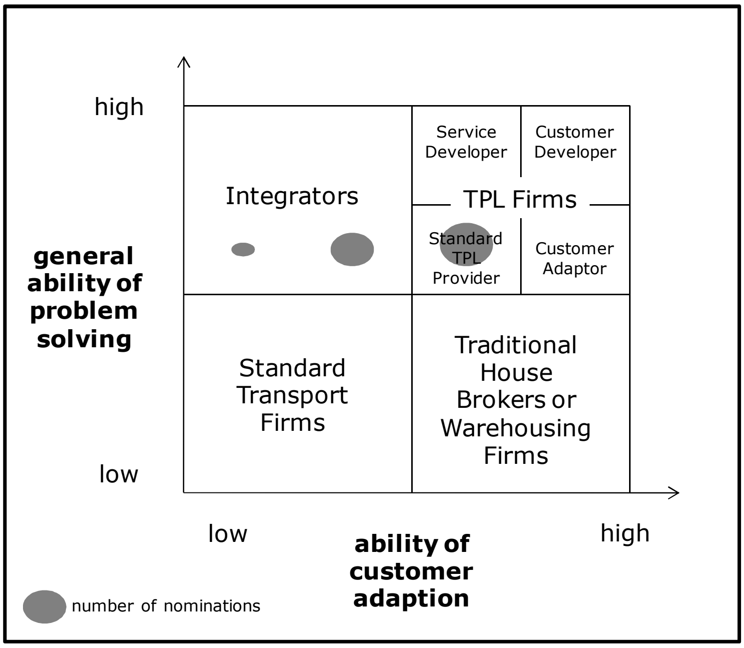


Figure 1: Positioning of Logistics Service Providers in Germany

Firstly, the positioning model displays two covered areas or rather two main groups of LSP in the German market: Integrators and Standard TPL Providers. The group of "Integrators" exhibits a high ability of solving general problems and are less capable to adapt to special needs of customers. Such Service Providers combine the assets of different partners in order to create transportation networks and offer standardised services (Hertz & Alfredsson 2003). Due to suchlike standardised services and processes the possibilities for customer adaption can be seen as low, since standardised services come along with a higher robustness but also a simultaneous lack in flexibility. The Standard TPL Providers can be seen as providing basic TPL services like warehousing and distribution in addition to the general transport services (Hertz & Alfredsson 2003), without providing high developed value adding services like e.g. the Customer Adaptor. The ability of general problem solving requires, beside others, resources in terms of cost focused work force, successful process management, physical asset base, and high quality IT-system, in order to establish cost efficient and robust processes. For the ability of customer adaption a LSP needs, beside others, creative and flexible work force, flexible processes and special knowledge, well established networks, and versatile IT-systems, in order to adapt to special customer demands through an open minded, creative and solution oriented system.

Secondly, the positioning model shows areas, which are not covered by LSP. One example are Standard Transport Firms, which are offering basic services like the A to B transport without a broad service portfolio or a high level of customisation. Traditional

House Brokers or Warehousing Firms offer a low range of services with a higher customisation (e.g. special storage services for customers). The non-occupation of the lower positions in the positioning model show that the changing conditions in logistics markets require a high level of problem solving ability and customer adaption, since customers demand for a service portfolio, which is standardised as well as adaptable to a certain degree. However, Standard Transport Firms as well as Traditional House Brokers or Warehousing Firms are part of logistics networks, which are driven by Integrators or Standard TPL Providers. Thereby, they serve as subcontractors whereas their individual service is part of the logistics network portfolio. The upper positions (Service Developer, Customer Adaptor and Customer Developer) constitute areas, which can be covered by Integrators or Standard TPL Providers through an adaption of the underlying resources.
Thirdly, the question occurs which resources are needed by Integrators and Standard TPL Providers for their positioning or rather their individual abilities? For the ability of general problem solving an Integrator needs beside others a successful process management in order to create standardised, efficient, and robust processes and establish economies of scale and scope. Thus, an Integrator’s task refers to the creation of robust processes with a high utilisation, in order to meet customers demand for reliable low cost services. Therefore, an Integrator also needs own physical assets (e.g. logistics buildings and transport equipment) in order to ensure the robustness of the processes through own control. These robust processes can be combined to reliable networks and can lead to a broad range of standardised services. Thus, a logistics Integrator can assure a high competence in solving general problems.

Fourthly, in order to become a Standard TPL Provider with a higher ability of customer adaption a service provider has to focus on the establishment of special knowledge (Bask 2001), in terms of analytical and logistics design skills (Berglund 1999) as well as flexible processes, which can be adapted to special customer needs. That means that the core task refers to the permanent analysis of customers’ individual problems and the subsequent design of own processes in order to solve suchlike changing exercises. Moreover, the Standard TPL Provider needs less physical assets but well-established networks (Person & Virum 2001). That results from the fact that through the connection of internal and external assets high flexible networks can be established and own assets can be combined with external ones according to the given customer problem.

OPTIONS FOR THE REPOSITIONING OF LSP IN GERMANY
Based on the current positioning and underlying resources three major options for the repositioning of LSP in Germany are possible: The improvement of the ability of general problem solving, the improvement of the ability of customer adaption or the improvement of both simultaneously.

First Option: Improve ability of customer adaption
The first option is to aim for the development from an Integrator or Standard TPL Provider to a Customer Adaptor. Thereby, the Customer Adaptor takes over the already existing activities of customers and aims for improving the efficiency of them without focusing on developments of services (Hertz & Alfredsson 2003). Regarding the development of creative and flexible work force logistics companies should focus on the establishment of an open minded, cooperative and innovation-supporting environment, in order to allow for creativity and advance solution-oriented thinking. An innovative environment can e.g. be established through the principle of self-organisation (Hülsmann & Cordes 2009) or through working in teams (Bea & Haas 2009). Flexible processes refer to the establishment of services, which are not highly standardised but can be adapted to special customer needs. In order to be flexible processes have to be established, which are independent from each other, in order to avoid bullwhip effects through the failure of several processes. That means that in case one process is changed other processes are not highly influenced. Regarding the special knowledge LSP have to invest in the development of the company’s knowledge base, which collects the organisational information. Such a knowledge base ensures the availability of relevant processes and services related knowledge, since the relevant know-how of several organisational members is accumulated and becomes available for the collective. In order to develop networks based on less physical assets LSP have to focus on cooperation activities. Thus,

flexible interfaces have to be established in order to allow for the connection and integration of network partners. Moreover, own processes have to be transparent and the LSP has to focus on the relationship development with e.g. subcontractors in the network. Also processes for searching, evaluating and controlling network partners have to be implemented in order to expand the network and ensure the highest efficiency in the cooperation. In order to provide versatile IT-systems LSP have to focus on modularised software components, which can be expanded with other modules if necessary. Also the IT-systems have to be highly compatible with other software respectively with the data of customers, since the solution of individual customer problems demand for an integration of specific problem-related data and information.

Second Option: Improve general ability of problem solving
The second option aims for the development from a Standard TPL Provider to a Service Developer. The Service Developer offers advanced value adding services for different customers whereas the services often consist of standardised services, which are adapted to special customer needs as modules (Hertz & Alfredsson 2003). Regarding the development of cost focused work force a company can establish a culture, which fits to such a cost focus strategy. That means to focus on values like economy, discipline and reliability in the whole organisation (Bea & Haas 2009). For a successful process management and the improvements of internal processes LSP have to focus on process innovations or rather an adequate innovation management (Flint et al. 2005), in order to permanently reorganise and update the underlying processes. A connection to research centres (e.g. universities) can also support innovation activities, since it can lead to absorption of new ideas and an application of theoretical approaches to practical problems. In order to establish an adequate base of physical assets a logistics company has to invest in up-to date and high-developed assets, in order to realise a high cost efficiency during their use in standardized processes. These up-to date assets can e.g. be environmentally friendly vehicles and buildings or highly developed logistics technologies (e.g. Radio-Frequency-Identification). Since the focus lays on cost efficiency these physical assets also have to be compatible to the existing asset base in order to establish economies of scope. High quality IT-systems for the support of robust processes can be established through the use of certified, highly developed and standardised hardware and software components or through the investment in such components offered by different external providers.

Third Option: Improve ability of problem solving and of customer adaption
The third option describes the development to a Customer Developer. These type of provider bases on a high integration of the customer and often covers the whole logistics activities. It requires a high level of know-how and constitutes the most difficult and advanced form of provider (Hertz & Alfredsson 2003), since it requires the highest level of general problem solving ability as well as customer adaption ability. In order to improve the general ability of problem solving as well as the ability of customer adaption LSP have to focus on different resources and on the balance between them. First the company has to combine own resources (e.g. management systems) with external resources in order to create logistics networks, which are able to offer a number of different but also highly customised services to competitive costs. Thus, the service provider has to focus on service innovation as well as on process innovation. The interfaces have to be highly flexible in order to integrate the whole customer data in the own processes as well as stable in order to provide all required information for the customer in every stage of service procedure. The network processes have to be flexible on the one hand in order to be adaptable to the special customer needs but also have to be stable in order to avoid failures. Also focusing on both, general problem solving ability and customer adaption can lead to a high complexity within a company because of managing and designing activities in a network which have to be highly adapted to special customer needs. Autonomous cooperation can be seen as one approach to balance flexibility and stability in logistics networks with the aim of high robustness (Hülsmann & Wycisk 2007, Hülsmann et al. 2011). Also the implementation of autonomous cooperation in a company can be assumed to lead to a pool of different alternatives, the promotion of creativity, and contributions to efficient problem solving through autonomous decision-making, the interaction of heterogeneous elements and an

improved handling of the system's overall complexity (Hülsmann & Wycisk 2007). Thus, autonomous cooperation as an organisation principle can contribute on both, the ability of general problem solving (through efficient problem solving) and the ability of customer adaption (creation of different alternatives, promotion of creativity) as well as the handling of complexity resulting from these abilities.

CONCLUSION

An adequate positioning in their environment is essential for LSP in order to differentiate from competitors and achieve competitive advantages. Thus, this research investigated the positioning of German LSP through an empirical study with ten logistics experts, based on the LSP ability of customer adaption and the ability of general problem solving. For the outline of repositioning options different resources were described in terms of options for their development and adaption. Three main results can be outlined: (1) The study showed a misfit between the estimated importance of the LSP abilities (high) and its estimated configuration (low). This leads to a need for repositioning of LSP in Germany. (2) The investigation showed the main positioning of LSP as Integrators and Standard TPL Providers. Thus, a number of uncovered fields could be outlined, which allows for potential repositioning. (3) It was shown that a LSP can reposition itself to an uncovered area through the development of resources like work force, processes or IT systems. Thereby, autonomous cooperation as organisational principle can contribute to a development of resources and the handling of complexity. From a managerial perspective it can be stated that in the areas, which are currently covered by LSP, the offered service portfolios are similar and thus a differentiation from competitors seems to be difficult. Thus, logistics managers have to focus on repositioning their company to less- or uncovered fields through the development of the company's resource base. A successful repositioning can lead to an outperforming of competitors and to the achievement of competitive advantages through the establishment of a differentiating and high customer value delivering service portfolio. Thus, repositioning activities should be and are already on the agenda of logistics companies (e.g. the LSP Kühne + Nagel focuses on their customer adaption ability or rather aims for becoming a Customer Adaptor at the moment (Klimm & Clausen 2011)). This research also demonstrated some options for the repositioning of LSP but it could only cover a limited number of resources and two possible dimensions of positioning models. Thus, further research could focus on an investigation of other resources and positioning model dimensions for LSP.

REFERENCES

Africk, J.M. & Calkins, C.S. 1994, "Does asset ownership mean better service?", *Transportation and Distribution,* vol. 35, no. 5, pp. 49-61.

Bask, A.H. 2001, "Relationships among TPL providers and members of supply chains: a strategic perspective", *Journal of Business & Industrial Marketing,* vol. 16, no. 6, pp. 470-486.

Bask, A.H. 1999, *Third party relationships in logistics services*, Helsinki School of Economics and Business Administration.

Bea, F.X. & Haas, J. 2009, *Strategisches Management,* Lucius & Lucius, Stuttgart.

Berglund, M. 1999, "Third-party logistics: is there a future?", *International Journal of Logistics Management,* vol. 10, no. 1, pp. 59-70.

Bortz, J. & Döring, N. 2006, *Forschungsmethoden und Evaluation : für Human- und Sozialwissenschaftler,* Springer Medizin Verlag Heidelberg, Berlin.

Bruhn, M. 2009, *Marketing: Grundlagen für Studium und Praxis,* Gabler Verlag / GWV Fachverlage GmbH, Wiesbaden.

Cooper, J., Browne, M. & Peters, M. 1994, *European logistics: markets, management and strategy,* Blackwell, Oxford.

Davis, D.F., Golicic, S.L. & Marquardt, A.J. 2008, "Branding a B2B service: Does a brand differentiate a logistics service provider?", *Industrial Marketing Management,* vol. 37, no. 2, pp. 218-227.

Delaney, R.V. 1991, "Trends in Logistics and U.S. World Competitiveness", *Transportation Quaterly,* vol. 45, no. 1, pp. 19-41.

Dornier, P., Ernst, R., Fender, M. & Kouvelis, P. 1998, *Global Operations and Logistics - Text and cases,* John Wiley & Sons, New York.

Flint, D.J., Larsson, E., Gammelgaard, B. & Mentzer, J.T. 2005, "Logistics Innovation: a Customer Value-Oriented Social Process", *Journal of Business Logistics,* vol. 26, no. 1, pp. 113-147.

Grant, R.M. 2005, *Contemporary Strategy Analysis,* 5th edn, Blackwell, Malden.

Hakansson, H. & Johanson, J. 1982, "Industriella Marknadsföringstrategier i Stal- och Skogsindustrierna" in *Företag i Nätwerk - Ny syn pa Konkurrenskraft*, eds. I. Hägg & J. Johanson.

Hertz, S. & Alfredsson, M. 2003, "Strategic development of third party logistics providers", *Industrial Marketing Management,* vol. 32, no. 2, pp. 139-149.

Hülsmann, M. & Cordes, P. 2009, "Autonomous Co-operation and Control in Complex Adaptive Logistic Systems - Contributions and Limitations for the Innovation Capability of International Supply Networks" in *COMPLEX 2009, Part 1, LNICST 4 - Proceedings of the First International Conference on Complex Sciences: Theory and Application, Shanghai, China.*, ed. J. Zhou, Springer, Berlin, pp. 1023-1032.

Hülsmann, M., Grapp, J. & Li, Y. 2008, "Strategic Adaptivity in Global Supply Chains - Competitive Advantage by Autonomous Cooperation", *International Journal of Production Economics, Special Issue: Manufacturing Systems – Strategy & Design,* vol. 114, no. 1, pp. 14-26.

Hülsmann, M., Korsmeier, B., Illigen, C. & Cordes, P. 2011, "Autonomous Co-operation of "Smart Parts": Contributions and Limitations to the Robsutness of Complex Addaptive Logistics Systems" in *Dynamics in Logistics*, eds. H.-. Kreowski, B. Scholz-Reiter & K. Thoben, Springer, Heidelberg, pp. 255-268.

Hülsmann, M. & Wycisk, C. 2007, "Autonomous Co-operation – A Way to Vitalize Organizations?" in *Understanding Autonomous Cooperation and Control – The Impact of Autonomy on Management, Information, Communication, and Material Flow*, eds. M. Hülsmann & K. Windt, Springer, Berlin, pp. 193-206.

Johnson, G. & Scholes, K. 2008, *Exploring corporate strategy : text & cases,* 8th edn, Financial Times Prentice Hall, Harlow.

Juga, J., Pekkarinen, S. & Kilpala, H. 2008, "Strategic positioning of logistics service providers", *International Journal of Logistics Research and Applications,* vol. 11, no. 6, pp. 443-455.

Klimm, L. & Clausen, S. 2011, *Kühne + Nagel krempelt Führung um* [Homepage of Financial Times Deutschland], [Online]. Available: http://www.ftd.de/unternehmen/handel-dienstleister/:aenderungen-bei-logistiker-kuehne-nagel-krempelt-fuehrung-um/60028499.html?query=kühne+&Suche=Suche [2011, 04/27].

Lemoine, W. & Dagnaes, L. 2003, "Globalisation strategies and business organisation of a network of logistics service providers", *International Journal of Physical Distribution & Logistics Management,* vol. 33, no. 3, pp. 209-228.

Narasimhan, R. & Das, A. 1999, "An empirical investigation of the contributions of strategic sourcing to manufactering flexibilities and performance", *Decision Sciences,* vol. 30, no. 3, pp. 683-718.

Person, G. & Virum, H. 2001, "Growth Strategies for Logistics Service Providers: A Case Study", *The International Journal of Logistics Management,* vol. 12, no. 1, pp. 53-64.

Porst, R. 2008, *Fragebogen - Ein Arbeitsbuch,* 1st edn, VS Verlag für Sozialwissenschaften, Wiesbaden.

Porter, M.E. 1996, "What is Strategy?", *Harvard Business Review,* , vol. 74, no. 6, pp. 61-78.

Saloner, G., Shepard, A. & Podolny, J. 2001, *Strategic Management,* John Wiley & Sons, New York.

Schary, P.B. & Skjott-Larsen, T. 2001, *Managing the global supply chain,* Copenhagen Business School Press, Copenhagen.

Siegele, L. 2002, "How About Now? - A Survey of the Real-Time Economy", *The Economist,* vol. 362, pp. 18-24.

Speh, T.W. 2008, "Innovative LSP services: The marketing challenge" in *Managing Innovation: The new competitive edge for logistics service providers*, ed. S.M. Wagner, Haupt, Bern, pp. 31-60.

Trommsdorf, V. & Paulssen, M. 1999, "Messung und Gestaltung der Markenpositionierung" in *Moderne Markenführung*, ed. F.R. Esch, Gabler, Wiesbaden, pp. 1047-1066.

Wheelen, T.L. 2006, *Strategic management and business policy,* Pearson Prentice Hall, Upper Saddle River, NJ.

Zikmund, W.G. 2003, *Business research methods,* Thomson/South-Western, Mason, Ohio.

LEAD LOGISTICS PROVIDERS FOR FOOD CHAIN MANAGEMENT – A LITERATURE REVIEW ON FEASIBILITY AND BENEFIT

Michael Hülsmann[1], Verena Brenner[2], Jacobs University gGmbH
[1]m.huelsmann@jacobs-university.de, [2]v.brenner@jacobs-university.de

Acknowledgement
This research was supported by the Cool Chain Group

INTRODUCTION

Food chain management has been subject to considerable changes over the past four decades (Bourlakis & Bourlakis, 2004). Especially logistics for temperature-sensitive products (perishables) have gained in importance due to changing consumer habits, stricter transport regulation and the increase of temperature sensitive products (Hasselmann, 2008). This field of logistics comprises among others a wide range of food products such as fresh fruit and vegetable. However, the delivery of high quality products represents huge challenges for handlers due to the extension of worldwide trade in perishable food and the consequentially rising transport distances (Brecht et al., 2003). Hence, industry experts estimate losses along the food chain to amount to 35% of the entire production (Vega, 2008).

The question is thus, how current management practices in food chain logistics can be improved to reduce unnecessary losses. As perishable food is characterised by the direct relation between the initial and the final product quality, the coordination along the entire food chain is of crucial importance (Ziggers & Trienekens, 1999). The increasing availability of cooling equipment and information technology is thereby already an important improvement, but has still not penetrated every part of the food chain (Ruiz-Garcia, Steinberger, & Rothmund, 2010). Many authors advocate therefore for an integration of processes and companies along the food chain (see Bienstock et al., 2008; Hill, Zhang, & Scudder, 2009; Waters, 2009). One discussed concept for integrated supply chain management is the Lead Logistics Provider (LLP), who integrates processes and agents along the supply chain (Bretzke & Klett, 2004). The LLP manages and controls the material and information flows from door-to-door. In addition, it either executes all logistic services internally or co-ordinates and supervises services effected by other logistics companies (Paskert, 2001). Therefore, this paper aims for an assessment of the feasibility and benefits of LLPs for food chain management.

After the introduction in the first section, the second section provides a literature review on causes and effects of frictions in food chains. For this review, information and data of more than 100 sources were analysed to identify weak points in food chains. The findings will be concretised in the third section for the model case of maritime food chains from South Africa to Europe. The information on flaws in food chain management will facilitate the development of a requirement profile for LLPs. In the fourth section, the concept of LLP will be presented. Its deployment in the automotive sector will be briefly depicted, to reveal possible contributions and limitations of the concept for the supply chain management. The fifth section discusses the application of the concept to food chains for fruits and vegetables. Therefore, case studies on performance improvements of food chains will be summarized and assessed for possible contributions of an LLP to realise such improvement processes. The findings will be related to the weak points analysed in section two and three to evaluate if the LLP can help to reduce them. In the sixth section concluding remarks are given.

MAJOR OBSTACLES IN FOOD CHAIN MANAGEMENT

The supply chain for fruits and vegetables generally comprises four to six steps from the farm to the consumer (Vahrenkamp & Siepermann, 2005). These steps are linked by the flow of the product, as well as by the accompanying information flow (Beamon, 1998). These two levels of the food chain have been investigated regarding their weak points. Obstacles were identified such as inadequate human and technical resources, process delays and lacking ability or commitment to improve the performance. On the level of the product flow, the employment of unqualified staff, temperature fluctuations at interfaces and delays in food chain processes were reported to be especially problematic.

A frequently mentioned obstacle in the product flow is a lack of qualified staff at all levels of the food chain (Fearne & Hughes, 1999; Littek, 2005; Meier, 1979). For instance, the loading of transport modes like reefer containers or reefer trucks by inadequately trained staff often leads to wrong positioning of pallets. Commonly, pallets should be loaded in a way, which allows free circulation of fresh air around and in between the packages to cool the products and to extract respiratory gases (Mercantila Publishers, 1989). If this airflow is disrupted due to wrong storage and blockage of the air tunnels, the products heat up and deteriorate faster. Therefore, it is of prime importance to employ personnel, which is trained in the handling of food to reduce unnecessary losses.

Another problem are temperature fluctuations at interfaces, when the product is handed from one company to the next (Drewry Shipping Consultants, 1990; Nunes, Emond, & Brecht, 2006; Panozzo & Cortella, 2008). The delivery to the supermarkets for instance can imply cold chain ruptures, as only few supermarkets are equipped with cooled reception areas (Smith & Sparks, 2004). Another example for ruptures has been observed at the airport of Miami, where pallets with perishables are left for hours on the hot apron (Nunes et al., 2006). Such fluctuations can damage the quality of the product significantly, even though they might last only a short period of time (Bogataj, Bogataj, & Vodopivec, 2005).

A third obstacle, which has been named repeatedly, are delays at all stages of the food chain (Nunes et al., 1995a; Nunes et al., 1995b; Nunes et al. 2009). Especially delayed pre-cooling has a negative impact on the product quality. For instance, a delay of pre-cooling of strawberries by two hours can lead to a loss of marketable fruits of ten percent (Paull, 1999). However, also delays at other stages of the cold chain imply a reduction of shelf life and contribute to food losses along the food chain and later at the consumer's home (Nunes et al. 2009).

Regarding the information flow, the literature names obstacles, such as inadequate infrastructure for information transmission, delays in information provision as well as the reluctance of companies to share data. One source of hindrance is that the increasing complexity and information demand in food chains is frequently relying on an inadequate infrastructure of information and communication technologies (ICT) (Van der Vorst et al., 1998). Furthermore, standards for food trade differ significantly between countries (MacMaoláin, 2007), leading to confusion and flaws in documentation. This problem is highlighted by a report conducted on the import refusals of food shipments by the U.S. Food and Drug Administration (FDA). It states that of 70,369 violations of laws imposed by the FDA, 33% were due to wrong or missing declarations and inadequate packaging (Buzby, Unnevehr, & Roberts, 2008). This example underlines the importance of careful information and documentation management to reduce unnecessary losses. Associated with the inferior information infrastructure are delays in information provision. If other companies do not submit pre-notifications of arrival in time, this can result in inadequate preparation and incorrect cooling of storage facilities (Trienekens et al., 2003). Moreover, customs authorities can retain shipments, if documents arrive late (Meier, 1979). Thus, by delayed information provision, shelf life is shortened directly and indirectly as the product arrives later at the point of sale.

The unwillingness of companies to share data is a general problem (Ramasodi, 2006), which hampers the performance of food chains. Retailers for instance were reported to be reluctant about sharing data with suppliers and partners in the food chain (Fearne & Hughes, 1999). If sales data is not available, suppliers cannot plan according to actual demand and the logistics performance is reduced (Custódio & Oliveira, 2006). Furthermore, opportunities to improve the food chain by synchronizing logistics processes are lost and 'island' solutions prevail (Trienekens et al., 2003).

THE CASE OF MARITIME FOOD CHAINS FROM SOUTH AFRICA TO EUROPE

In order to illustrate the problems encountered in a particular market and chain specific context, literature on maritime food chains from South Africa to Europe has been analysed.

Since its deregulation in 1997, the South African exports market for fresh food faces considerable changes (van Dyk & Maspero, 2004). Numerous export companies have replaced the previously centralized export channel, which has led to a fragmentation of the market and a dispersal of formerly concentrated expertise (Polderdijk et al. 2006). Furthermore, competition from other companies, but also from other countries has grown and prices have dropped (Trienekens & Ziggers, 2007). These developments contribute to the complexity encountered in the export market and threaten the competitiveness of South Africa in the international fresh food trade (van Dyk & Maspero, 2004). As is the case for food chains in general, the South African workforce in the food export market is low skilled and normally employed only on short-term contracts (Polderdijk et al., 2006). In addition, huge distinctions between black and white employees and a resulting lack of trust have been reported (Trienekens & Ziggers, 2007). These factors hinder the reduction of friction losses on the company, as well as on the food chain level. Furthermore, opportunistic sales behaviour of producers causes information asymmetry in the food chain. Consequently, forecasts used by exporters and transporters for logistical planning are inefficient and can increase costs (Trienekens & Ziggers, 2007). The obstacles encountered in the literature show that there is an urgent need to improve food chain management on the product flow level, as well as on the information flow level. Additionally, the example of South Africa shows that market specific conditions also have to be considered to remove obstacles for improved food chain management. Moreover, every link from the farm to the supermarket can be part of defects and should therefore be subject to improvement processes. The question is, how this process can be adequately managed and controlled and who should be in charge.

THE CONCEPT OF THE LEAD LOGISTICS PROVIDER

One option for the management and control of supply chains is the LLP. The LLP is frequently regarded as a combination of Third-Party-Logistics Providers (3PL) and Fourth-Party-Logistics Providers (4PL) (Zadek, 2004).

The 3PL is an external provider of logistics services, which are outsourced along the supply chain (Reindl, 2002). It possesses own logistical assets and offers specific services according to its competences. In general, this does not include IT solutions for the entire supply chain (Delfmann & Nikolova, 2002). The advantage of 3PLs is frequently seen in the possession of own logistics assets, as practical experience is regarded as an indicator of required competences for the management of supply chains. A disadvantage in turn is that the possession of assets might induce the 3PL to replace the optimal supply chain solution in favour of higher capacity utilization of own assets (Schulte, 2009).

The concept of 4PL stands for the idea of a service company, which coordinates all logistics processes of the supply chain for its customer, without the possession of own logistics assets (Zadek, 2004). The 4PL acts as a planning and coordinating entity, which uses modern IT solutions for assuring the seamless flow of products and information between the different logistics service providers (Schulte, 2009). The advantage of the 4PL in comparison to the 3PL is that its single aim is to provide services to the satisfaction of its customers. However, due to the lack of assets, potential customers might doubt the expertise for managing the supply chain (Zadek, 2004).

The LLP in turn, frequently evolves from a 3PL, which amends its service portfolio with IT solutions (Baumgarten, Darkow, & Zadek, 2004). The requirements posed by the customers are first of all the fulfilment of logistics activities. Additionally, they include technical knowledge, experience in all sub-activities, coordination abilities, a global network, as well as resources and competences in ICT (Reindl, 2002). Due to the elevated demands regarding expert knowledge, the LLP normally focuses on a specific group of customers or the same kind of products (Gudehus, 2011). Its advantage is that it combines the possession and utilization of own logistical assets with the service offer especially designed for the customer (Baumgarten et al., 2004). Additionally, an advantage for the customer is the one-stop-shopping solution for all logistics activities and the reduction of coordination efforts (Reindl, 2002).

Whereas the concept of the 4PL is still a more theoretical approach (Schulte, 2009), the LLP is already successfully in use in the industry as for example in the automotive sector. The automotive sector is characterized by a complex and large network of suppliers, which can consist of 500 to 1.500 companies and hundreds of Logistics Service Providers (Zadek, 2004). The tasks of the LLP include for instance the optimization of transport routes, the information flow management and the supplier management (Corsten & Gabriel, 2004). The LLP needs to be able to assure that the materials are at the right time at the right location. This is difficult due to the spread of just in time deliveries (Aigbedo, 2007). Reasons for outsourcing logistics activities in the automotive sector are for instance a preferable cost structure, reduction of capacity needs, more efficient bundling of product and information flows, and flexible reaction to demand variations (Klug, 2010). An example for the successful implementation of LLP in the automotive sector is the outsourcing of all logistics activities by General Motors (GM). Over a three years transition period, GM transferred the daily management of about 180 million pounds of material required from more than 12,000 suppliers to one strategic partner, the LLP (Wisner, Leong, & Tan, 2005). Considering the huge number of companies, which have to be coordinated from distant places and with different backgrounds, cultures and business environments, the assurance of the material and information flow is a complex task (Schonert, 2008), which the LLP handles for its customer.

The establishment of LLPs in food chains, which for instance link farmers in emerging countries with powerful retailers in Europe and where the smooth product and information flow is crucial, might help to improve the performance. Therefore, possible contributions and limitations of the concept for improved food chain management will be discussed in the next section.

FEASIBILITY AND BENEFITS OF LEAD LOGISTICS PROVIDERS IN FOOD CHAIN MANAGEMENT

As already mentioned at the beginning, LLPs are not well established in food chains, yet. Nevertheless, some of its basic features, such as strategic partnerships between customers and service providers, outsourcing of logistics activities to one service provider and an integrated information and communication infrastructure, have already been analysed in empirical studies and pilot projects. The major findings are reported hereafter.

A study conducted by FEARNE (1998) analyses the performance effects of partnerships in the British beef industry. The author surveyed 2.000 farmers and some of the largest buyers and producers in the beef industry. The conclusions are that value-adding partnerships lead to competitive advantages, long-term profitability and consumer confidence. Additionally, market risk is reduced, investments decisions easier to take, reliability increased and joint learning enhanced (Fearne, 1998).

The LLP is considered as a long-term partner in the supply chain management of its customer (Notheis, 2003). The obstacles observed in food chains illustrated in section two, as the reluctance to share data and the threat of opportunistic behaviour, is at least partly due to short-term contracts between food chain agents (Trienekens & Ziggers, 2007). If the agents would instead focus on long-term contracts, as is done by integrating LLPs, uncertainties could be reduced and trusting relationships enhanced. Therefore, establishing long-term partnerships with LLPs in food chains is likely to allow for joint optimisation as indicated by FEARNE. Nevertheless, the cooperation has also to be extended to suppliers and customers, and has to include other business areas, which are not managed by the LLP, as for example the area of marketing.

HSIAO ET AL. (2010) tested in a survey the effects of outsourcing logistics activities on the service performance of food processing companies from the Netherlands and Taiwan. They come to the conclusion that benefits of outsourcing all logistic activities to one logistics service provider increases with higher complexity of demand (Hsiao, van, Kemp, & Omta, 2010). Furthermore, they argue that an advantage of outsourcing all logistics activities helps the food processing companies to concentrate on their core competencies.

As has been shown in the case of GM, the advantage of outsourcing logistics activities to one LLP is already recognised. Regarding complex business environments, the case of the South African food chain has shown that complexity of demand is indeed a major issue. Consequently, appointing a LLP for the forecasting, planning and execution of transport and supply chain management can enable food chain companies to focus on their core competences and to reduce the complexity of their business. Nevertheless, LLPs can only be one part of assuring the competitiveness of South African food exporters. Other factors, such as improved marketing of South African products and coping with the new market structure, have also to be considered.

Enhanced information sharing can have a positive effect on the food quality, too. VAN DER VORST ET AL. (1998) investigated the impact of supply chain management on logistical performance indicators in food supply chains. In a pilot project, they found out that by information sharing between supply chain agents, freshness of salads at distribution centres increased by 3.8 days and inventory levels were reduced by 1.9 days of stock (Van der Vorst et al., 1998). These findings are supported by KETZENBERG & FERGUSON (2008), who tested in a numerical study the effects of information sharing between one retailer and one supplier. They found out that by decentralised information sharing, product freshness increased by 18.3% and overall supply chain profits were predicted to rise by 4.2% (Ketzenberg & Ferguson, 2008).

To share information with customers and suppliers can be seen as a precondition for strategic partnerships and joint improvement of supply chains (Waters, 2009). As already indicated above, in contrast to the employment of several logistics service providers, the use of LLPs implies long-term contracts (Notheis, 2003). Thereby, barriers to information sharing are reduced. Furthermore, commonly specifying data definitions helps to reduce uncertainty in daily food chain management (Trienekens & Willem Ziggers, 2007). By agreeing on definitions, the observed flaws in documentation can thus become less critical. However, even if the LLP can contribute to the standardisation of documents and data definition, its impact remains restricted by inharmonious regulatory demands.

Another survey, conducted by STANK ET AL. (1999) among 47 food companies, deals with the impact of inter-firm application of EDI and ICT on key logistics performance indicators. They find out that the use of EDI and ICT between companies of the food chain compresses the order cycle and improves inventory management. Additionally, they point out that for improvements, performance monitoring is also of crucial importance (Stank, Crum, & Arango, 1999).

Regarding the inferior infrastructure for information and communication observed in food chains, one of the advantages of LLPs is that they provide a wide range of IT Services, which are adapted to the customers' needs. Whereas frequently managers of food chain companies are reluctant to invest in powerful ICT (Alfaro & Rabade, 2009), it is one of the core competencies and business purposes of LLPs. Therefore, the transfer of all logistics activities, of the accompanying information, and of monitoring tasks, to one LLP might help to establish an efficient ICT infrastructure. However, even though the major part of investments is done by the LLP, its customers will also have to make amendments and to invest in their IT systems.

CONCLUDING REMARKS

The LLP can help to establish strategic partnerships, enables the concentration on core competencies by the involved food chain companies, and provides the infrastructure for an integrated ICT. This might result in benefits such as long-term profitability, improved service performance, increased product freshness and an efficient information and product flow. However, there are also limitations to improving food chain management by establishing LLPs. The LLP does not control the trading partners, such as suppliers, of its customer. Its potential influences are limited, as for example regulatory constraints persist. Actors in food chains still have to take investments in ICT, which they frequently try to avoid. Consequently, improvements might be restricted to logistics food chain activities, while external restrictions remain. Furthermore, the dependency of successful food chain management on key decision makers is likely to continue.

There are some methodological constraints: First of all, the findings of the case studies do not necessarily apply to food chains in general, but might be dependent on specific food chain constellations. Additionally, it is unclear to which extent these results can be transferred to the concept of LLPs. Finally, it should be noted that the practical application of LLPs to food chain management has not been realised and analysed, yet. Therefore, further research should concentrate on providing more information on features and characteristics of LLPs in comparison to currently employed logistics service providers in food chains. Moreover, the practical application and the actual use of LLPs in food chains as well as the effects on food chain performance need to be analysed.

These findings indicate that on the one hand, there are numerous human-related and technology-related flaws in the information and product flow, which have not been tackled, yet. This inferior management of food chains implies significant friction losses and wastage of resources. On the other hand, the case studies revealed that food trading companies and logistics service providers can considerably improve their performance in terms of service, profitability and competitiveness. Food chain companies should therefore consider changing current practices by focussing on strategic partnerships, concentration on core-competencies and the integration of ICT along the food chain. To employ LLPs might contribute to the reduction of flaws and losses in food chains.

REFERENCES

Aigbedo, H. (2007), An assessment of the effect of mass customization on suppliers' inventory levels in a JIT supply chain, *European Journal of Operational Research, 181*(2), pp. 704-715.

Alfaro, J. A., & Rabade, L. A. (2009), Traceability as a strategic tool to improve inventory management: A case study in the food industry, *International Journal of Production Economics, 118*(1), pp. 104-110.

Baumgarten, H., Darkow, I. L., & Zadek, H. (2004), Strategien für Logistikdienstleister, in H. Baumgarten, I. L. Darkow & H. Zadek (Eds.), *Supply Chain Steuerung und services: Logistik-Dienstleister managen globale Netzwerke - best practices* (pp. 167-178) Berlin et al., Springer.

Beamon, B. M. (1998), Supply chain design and analysis: Models and methods, *International Journal of Production Economics, 55*(3), pp. 281-294.

Bienstock, C. C., Royne, M. B., Sherrell, D., & Stafford, T. F. (2008), An expanded model of logistics service quality: Incorporating logistics information technology, *International Journal of Production Economics, 113*(1), pp. 205-222.

Bogataj, M., Bogataj, L., & Vodopivec, R. (2005), Stability of perishable goods in cold logistic chains, *International Journal of Production Economics, 93-94, 345-356.*

Bourlakis, C., & Bourlakis, M. (2004), The future of food supply chain management, in M. Bourlakis, & P. Weightman (Eds.), *Food supply chain management* (pp. 221-230), Oxford et al., Blackwell Publishing.

Brecht, J. K., Chau, K. V., Fonseca, S. C., Oliveira, F. A. R., Silva, F. M., Nunes, M. C. N., et al. (2003), Maintaining optimal atmosphere conditions for fruits and vegetables throughout the postharvest handling chain, *Postharvest Biology and Technology, 27*(1), pp. 87-101.

Bretzke, W., & Klett, M. (2004), SCEM als Entwicklungspotenzial für Logistikdienstleister, in H. Beckmann (Ed.), *Supply Chain Management: Strategien und Entwicklungstendenzen in Spitzenunternehmen* (pp. 155-181), Berlin et al., Springer.

Buzby, J. C., Unnevehr, L. J., & Roberts, D. (2008), Food safety and imports - an analysis of FDA food-related import refusal reports, *Economic Research Service Information Bulletin, 39*

Corsten, D., & Gabriel, C. (2004), *Supply Chain Management erfolgreich umsetzen: Grundlagen, Realisierung und Fallstudien,* Berlin et al., Springer.

Custódio, A. L., & Oliveira, R. C. (2006), Redesigning distribution operations: A case study on integrating inventory management and vehicle routes design, *International Journal of Logistics: Research & Applications, 9*(2), pp. 169-187.

Delfmann, W., & Nikolova, N. (2002), Strategische Entwicklung der Logistik – Dienstleistungsunternehmen auf dem Weg zum X-PL?, in Bundesvereinigung Logistik, Wissenschaftssymposium Logistik der BVL 2002, München: pp. 421-435.

Drewry Shipping Consultants. (1990), *Reefer container market: Progress in the containerised transport of perishable commodities 1987-2000*, London: Drewry Shipping Consultants.

Fearne, A. (1998), The evolution of partnerships in the meat supply chain: Insights from the british beef industry, *Supply Chain Management: An International Journal, 3*(4), pp. 214-231.

Fearne, A., & Hughes, D. (1999), Success factors in the fresh produce supply chain: insights from the UK, *Supply Chain Management: An International Journal, 4*(3), pp. 120-131.
Gudehus, T. (2011), *Logistik: Grundlagen - Strategien – Anwendungen*, Berlin, Heidelberg, Springer-Verlag.
Hasselmann, G. (2008), Temperaturgeführte Transporte, in D. Arnold, H. Isermann, A. Kuhn, H. Tempelmeier & K. Furmans (Eds.), *Handbuch Logistik* (3rd ed., pp. 570-579), Berlin et al., Springer.
Hill, C. A., Zhang, G. P., & Scudder, G. D. (2009), An empirical investigation of EDI usage and performance improvement in food supply chains, *IEEE Transactions on Engineering Management, 56*(1), pp. 61-75.
Hsiao, H. I., Kemp, R. G. M., van der Vorst. J.G.A.J, & Omta, S. W. F. (2010), Developing a decision-making framework for levels of logistics outsourcing in food supply chain networks, *International Journal of Physical Distribution & Logistics Management, 40*(5), pp. 395-414.
Ketzenberg, M., & Ferguson, M. E. (2008), Managing slow-moving perishables in the grocery industry, *Production and Operations Management, 17*(5), pp. 513-521.
Klug, F. (2010), *Logistikmanagement in der Automobilindustrie: Grundlagen der Logistik im Automobilbau*, Berlin et al., Springer.
Littek, F. (2005), *Kühltransport: Temperaturgeführte Logistik und Transporttechnik*, Bergen/Dumme, Agrimedia.
MacMaoláin, C. (2007), *EU food law: Protecting consumers and health in a common market*, Oxford et al., Hart.
Meier, T. (1979), Probleme des temperaturgeführten Verkehrs aus der Sicht der Transportunternehmer, Thesis, University of Applied Science Bremerhaven.
Mercantila Publishers. (1989), *Guide to food transport: Fruit and vegetables*, Copenhagen, Mercantila Publ.
Notheis, D. (2003), Moderne Kapitalmarktstrategien für Logistikunternehmen, in H. Merkel, & B. Bjelicic (Eds.), *Logistik und Verkehrswirtschaft im Wandel: Unternehmensübergreifende Versorgungsnetzwerke verändern die Wirtschaft; Festschrift für Gösta B. Ihde* (pp. 507-521), München, Vahlen.
Nunes, M. C. N., Brecht, J. K., Morais, A. M. M. B., & Sargent, S. A. (1995a), Physical and chemical quality characteristics of strawberries after storage are reduced by a short delay to cooling, *Postharvest Biology and Technology, 6*(1-2), pp. 17-28.
Nunes, M. C. N., Brecht, J. K., Sargent, S. A., & Morais, A. M. M. B. (1995b), Effects of delays to cooling and wrapping on strawberry quality (cv. sweet charlie), *Food Control, 6*(6), pp. 323-328.
Nunes, M. C. N., Emond, J. P., & Brecht, J. K. (2006), Brief deviations from set point temperatures during normal airport handling operations negatively affect the quality of papaya (carica papaya) fruit, *Postharvest Biology and Technology, 41*(3), pp. 328-340.
Nunes, M. C. N., Emond, J. P., Rauth, M., Dea, S., & Chau, K. V. (2009), Environmental conditions encountered during typical consumer retail display affect fruit and vegetable quality and waste, *Postharvest Biology and Technology, 51*(2), pp. 232-241.
Panozzo, G., & Cortella, G. (2008), Standards for transport of perishable goods are still adequate?, *Trends in Food Science & Technology, 19*(8), pp. 432-440.
Paskert, D. (2001) Der integrierte Logistikdienstleister als Partner im Supply Chain Management, in W. Feldkamp, & H. Pfohl (Eds.), *Jahrhundert der Logistik: Wertsteigerung des Unternehmens: Customer related - glocal - e-based; 16. Fachtagung Institut für Logistik, 12. Juni 2001, Darmstadt* (pp. 61-83), Berlin, E. Schmidt.
Paull, R. E. (1999), Effect of temperature and relative humidity on fresh commodity quality, *Postharvest Biology and Technology, 15*(3), pp. 263-277.
Polderdijk, J. J., van Dyk, F. E., Ferreira, D., Guis, G. W., & Keller, S. (2006), Integrated supply-chain information system for fruit produce between South Africa and the Netherlands, *Wageningen UR Frontis Series: Agro-Food Chains and Networks for Development, 14*.
Ramasodi, M. N. (2006), Outsourcing in the cold supply chain of subtropical fruits: A case study, Thesis, University of Johannesburg.

Reindl, M. (2002), *eLogistics: Logistiksysteme und -prozesse im Internetzeitalter*, München et al., Addison-Wesley.
Ruiz-Garcia, L., Steinberger, G., & Rothmund, M. (2010), A model and prototype implementation for tracking and tracing agricultural batch products along the food chain, *Food Control, 21*(2), pp. 112-121.
Schonert, T. (2008), Interorganisationale Wertschöpfungsnetzwerke in der deutschen Automobilindustrie: Die Ausgestaltung von Geschäftsbeziehungen am Beispiel internationaler Standortentscheidungen, Wiesbaden, Gabler.
Schulte, C. (2009), *Logistik: Wege zur Optimierung der Supply Chain*, München, Vahlen.
Smith, D., & Sparks, L. (2004). Temperature controlled supply chains, in M. A. Bourlakis, & P. W. H. Weightman (Eds.), *Food supply chain management* (pp. 179-198), Oxford et al., Blackwell Publishing.
Stank, T., Crum, M., & Arango, M. (1999), Benefits of interfirm coordination in food industry supply chains, *Journal of Business Logistics, 20*(2), pp. 21-42.
Trienekens, J. H., Hagen, J. M., Beulens, A. J. M., & Omta, S. W. F. (2003), Innovation through (international) food supply chain development: A research agenda, *International Food and Agribusiness Management Review, 6*(1).
Trienekens, J. H., & Ziggers, W. S. (2007), Innovation and governance in international food supply chains: The cases of Ghanaian pineapples and South African grapes, *International Food and Agribusiness Management Review, 10*(4), pp. 42-63.
Vahrenkamp, R., & Siepermann, C. (2005), *Logistik: Management und Strategien*, München et al., Oldenbourg.
Van der Vorst, J. G. A. J., Beulens, A. J. M., Wit, W., & Beek, P. (1998), Supply chain management in food chains: Improving performance by reducing uncertainty, *International Transactions in Operational Research, 5*(6), pp. 487-499.
van Dyk, F. E., & Maspero, E. L. (2004), Analysis of the South African fruit logistics infrastructure, *Orion: The Journal of ORSSA, 20*(1).
Vega, H. (2008), Air cargo, trade and transportation costs of perishables and exotics from South America, *Journal of Air Transport Management, 14*(6), pp. 324-328.
Waters, C. D. J. (2009), *Supply chain Management: An introduction to logistics*, Basingstoke et al., Palgrave Macmillan.
Wisner, J. D., Leong, G. K., & Tan, K. (2005), *Principles of supply chain management: A balanced approach*, Mason et al., South-Western Cengage Learning.
Zadek, H. (2004), Struktur des Logistik-Dienstleistungsmarktes, in H. Baumgarten, I. L. Darkow & H. Zadek (Eds.), *Supply Chain Steuerung und Services: Logistik-dienstleister managen globale Netzwerke - best practices* (pp. 15-28), Berlin et al., Springer.
Ziggers, G., & Trienekens, J. (1999), Quality assurance in food and agribusiness supply chains: Developing successful partnerships, *International Journal of Production Economics,* 60-61, pp. 271-279.

AN ANALYSIS ON THE NATIONAL LOGISTICS EFFICIENCY WITH DEA

Kune-muh Tsai[1,*] *Mei-hui Chen*[2]
[1,*] Department of Logistics Management, National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan 811
kmtsai@ccms.nkfust.edu.tw
[2] Department of Cosmetic Science, Chia Nan University of Pharmacy and Science
Tainan, Taiwan 717

ABSTRACT
National logistics efficiency has seldom been addressed in previous research despite its importance in measuring the logistics scale and performance of a country. Some reports on national logistics expenditures regard the expenditure as the scale of logistics industry of a country, and the ratio of the expenditure to the national GDP (gross domestic product) as the logistics efficiency of a country. These two measures can somehow demonstrate the scale and efficiency of the national logistics industry. However, they are sometimes misleading and contradicting since under the same GDP, larger logistics expenditure means larger scale of logistics industry but lower logistics efficiency. Therefore, from a country's perspective, should the country lower or increase the logistics expenditure for the welfare of it.
In this study, we utilize data envelopment analysis (DEA) to evaluate and compare the logistics efficiency of 10 countries in different continents such as the U.S., Japan, Korea, Taiwan, China, Germany, Holland, etc. The input variables are logistics-related ones such as the national logistics expenditure and other inputs, and the output variables are GDP and others that can represent the performance of a country from logistics-related inputs. Three different DEA models, the CCR, BCC and simple cross-efficiency analysis, are implemented for the performance analysis and comparison. From the results of the three DEA models, we further divide the national logistics efficiency of the 10 nations into three categories.

KEYWORDS
Logistics efficiency, National logistics expenditure, Data envelopment analysis, GDP

INTRODUCTION
From the inbound to the outbound, logistics operations occur at every place around a business. They affect the performance of a business, from manufacturing to market support. Hill (2010) regarded the logistics cost as one of the competitive advantages of a nation, which is getting more significant for the increase of international trade in shaping the competiveness of a nation. Logistics operations are bounded to other kinds of operations; therefore, it is usually difficult to accurately separate them and calculate the cost of logistics, including inventory, material handling, transportation, etc. Even though the national logistics expenditure (NLE) represents the cost consumed by the nation for logistics services, it also stands for the scale of the nation's logistics-related industries, e.g. trucking, waterline shipping, warehousing, and forwarding. and affects industries such as the information service providers, makers of cargo transporters and warehouse equipment. With information on NLE, governments can have a better foundation in setting up the development strategy for its logistics-related industries. However, direct measurement or computation of NLE is not applicable because it requires detailed data on all the logistics components (Bowersox et al., 2003). Actually, what kinds of logistics components should be included for the computation and whether the related data are available are still doubtful and dubious even in most developed nations, let alone for most other countries (Bowersox et al., 2003).

The study of Hesket et al. (1973) was the first one to propose a model for estimating NLE. In the model, they projected the logistics total cost as the sum of four types of activities, including transportation, inventory, warehousing and order processing. Most of the required data can be obtained from the statistics of the census of the U.S., but the parameters of the data on the total cost are estimated by the model. Delaney and Wilson (2003) later modified the aforementioned model to quantify the logistics expenditure of the U.S. and have continued to estimate the NLE with their new model ever since. The works of Hesket et al. (1973) and Delaney and Wilson (2003) set a foundation for estimating the logistics expenditure of a nation, which are adopted by many countries, including Japan, Korea, Taiwan, and China, with some adjustments for measuring their own countries.

Most nations in the world do not regularly compute and publicize their logistics costs because of incomplete data or neglecting it. Hence, it is very difficult to obtain the NLE of other countries. Bowersox viewed this as a problem and conducted a series of research with neural networks to estimate the NLE of major countries which accounted for 75% of the world GDP (Bowersox and Calatone, 1998; Bowersox et al., 2003; Rodigrgues et al., 2005). The inputs of their models are mainly the statistics of the nation and include geographic region variables (based on the continent where the nation is in), income level variables (5 levels of income ranged from low to high), country size variables (i.e. area, urban population and coastline), economy variables (i.e. GDP, import amount, export amount, trade openness, agriculture, industry and service amounts) and transportation variables (i.e. maritime freight amount and road, rail and air freight amount). The output is the NLE based on their purpose. The aforementioned models are valuable in estimating the NLE of many nations without regular computing and publicizing their logistics costs. However, some of the training data sets are only estimation rather than real data because the latter is very difficult to obtain. Thus, the result can only be used as a reference for the NLE or a comparison among nations. Besides, the results of their studies still have difficulty in comparing the efficiency on a national level because the only index presented is the ratio of the NLE to the GDP. Nevertheless, even Bowersox and his colleagues did not mention the relationship between the ratio and national logistics efficiency for such relationship is paradoxical and sometimes contradicting.

Data envelopment analysis (DEA) has been widely used in analyzing multiple decision-making units (DMUs) with multiple inputs and multiple outputs (Lin and Hong 2006). For a nation, the NLE is a cost spent on logistics activities to support businesses and the society in all aspects; in the meantime, it also represents the scale of logistics-related industries of the nation. Another problem for NLE is that neither we are sure whether NLE had better be larger or smaller nor we are sure about the ratio between NLE and GDP. But, we do believe that logistics efficiency is a mix of variables, including NLE and other national-related ones instead of a simple index like NLE/DGP or the amount of the NLE itself. Due to the special characteristics of DEA in analyzing and comparing the performances of different decision-making units (which are nations in our study), we consider that DEA can be a good method for evaluating logistics efficiency and making the comparison among nations.

EXPERIMENTS AND RESULTS

In this study, we utilize DEA to evaluate and compare the logistics efficiency of 10 countries in different continents, including the U.S., Japan, Korea, Taiwan, China, Germany, Holland, etc. Based on the variables presented in past studies (Bowersox and Calatone, 1998; Bowersox et al., 2003; Rodigrgues et al., 2005) and the results generated from performing the Person test to exclude input variables that are irrelevant to the outputs, we employ four logistics-related variables as inputs including NLE, ICT (information and communication technology) usage rate (the number of users in telephones + wireless phones + broadband divided by the population), road density (the length of roads divided by the area of the nation) and railway density (the length of railways divided by the area of the nation). The outputs are the nation's external performance including GDP and import + export amount of the nation. The nation's fundamental data are obtained from the World Bank (2007) and the NLE are obtained from the respective logistics associations of the nations such as the CSCMP 19th Annual State of Logistics Report for that of the U.S., the Logistics Expenditure Report of 2007 by Japan Institute of Logistics Systems for that of Japan, 2007 Logistics Annual Report of Taiwan by the Department of Economics of Taiwan for that of Taiwan, and so on.

Three different types of DEA models, namely the CCR (Charnes et al., 1978), BCC and simple cross-efficiency analysis, are implemented for the performance analysis and comparison. The CCR model is developed to measure the overall production efficiency of

DMUs under constant return to scale (CRS) conditions. Higher efficiency value means higher total efficiency for the DMUs, and the largest having a value of 1. The BBC model (Banker et al., 1984) is to measure the efficiency resulted from pure technology (excluding the effect of scale). The model loosens the restriction of the CCR model to variable return to scale (VRS). Therefore, the ratio of CCR/BCC represents the efficiency resulted from the scale. The simple cross-efficiency model is developed as an extension to the efficiency values obtained from the CCR and BBC models and is referred to as self-appraisal.

Table 1 Efficiency values, number of references and ranking of ten nations

Nations (DMUs)	CCR model (ranking, number of references)	BBC model (ranking, number of references)	CCR/BCC	Simple cross efficiency model (ranking)
Australia	1.000(1, 4)	1.000 (1, 2)	1.000	0.972(1)
China	0.488(9, 0)	1.000 (1, 1)	0.488	0.428(10)
India	0.685(8, 0)	1.000 (1, 1)	0.685	0.536(8)
Japan	1.000 (1, 4)	1.000 (1, 1)	1.000	0.903(3)
Korea	0.753(7, 0)	0.755(10, 0)	0.998	0.711(5)
Holland	1.000 (1, 3)	1.000 (1, 2)	1.000	0.945(2)
Norway	1.000 (1, 1)	1.000 (1, 0)	1.000	0.676(7)
Taiwan	0.821(6, 0)	1.000 (1, 0)	0.821	0.706(6)
Thailand	0.479(10, 0)	0.977(9, 0)	0.490	0.444(9)
U.S.	1.000 (1, 0)	1.000 (1, 0)	1.000	0.860(4)

The above results exhibit different efficiency values with diverse models. From the perspective of the CCR model, Australia, Japan, Holland, Norway and the U.S. are in general more efficient than other nations. The BBC model disregards the scale effect and reflects only the technology implemented for the efficiency and most nations except Korea and Thailand have a value of 1. The CCR/BCC values show the efficiency from the scale, and the results reveal that Australia, Japan, Holland, Norway and the U.S. have a value of 1. The simple cross-efficiency model is for the self-appraisal efficiency, and the results show that Australia ranks number 1, followed by Holland, Japan and the U.S. From Table 1, we can further divide the ten nations into three groups. Group 1 is high in self-appraisal efficiency (simple cross-efficiency model) and the overall efficiency (CCR model and the reference numbers), and Australia, Japan and Holland are belonged to this group. Group 2 is in the middle of the self-appraisal and overall efficiencies, and the U.S., Norway, Taiwan and Korea are categorized in this group. Group 3 is in the lower of the self-appraisal and overall efficiencies, and India, Thailand and China are classified in this group.

CONCLUSION

Our study implements DEA to analyze and compare the logistics efficiency of ten nations by means of the CCR, BBC and simple cross efficiency models. Since different models display diverse rankings, we further classify the ten nations into three groups based on the self-appraisal efficiency and the overall efficiency. The nations in Group 1 are high in self-appraisal and overall efficiencies and can be referenced as benchmarks for other nations. On the contrary, those in Group 3 are low in self-appraisal and overall efficiencies and, thus, can learn from nations in Group 1 to improve their efficiencies.

In conducting the study, the major difficulty results from the unavailability and inaccessibility of data, especially the NLE that is published by the representative association of the nation. Moreover, despite the obtainment of the NLE from ten nations, we are still not sure whether they are based on the same modeling and computation foundation or not. Future research can extend our study to incorporate more nations in the model. Moreover, future research can further process the NLE they obtain based on the same foundation so as to achieve a more objective comparison result.

REFERENCES

Banker, R.D., Charnes, A. and Cooper, W.W (1984). Some model for estimating technical and scale inefficiencies in data envelopment anaylss. *Management Science* 30, 1078-1092.

Bowersox, D. and Calantone, R.J. (1998). Executive insights: Global logistics. *Journal of International Marketing* 6(4), 83-93.

Bowersox, D., Calantone, R.J. and Rodrigues, A.M. (2003). Estimation of global logistics expenditures using neural networks. *Journal of Business Logistics* 24(2), 21-36.

Charnes, A., Cooper W.W. and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research* 2(6), 429-444.

Delaney, R.V. and Wilson, R. (2003). *14th Annual State of Logistics Report: The Case for Reconfiguration*, Washington, DC: Cass Information Systems and ProLogis.

Heskett, J.L., Glaskowsky, N.A., Ivie, R.M. (1973). *Business Logistics-Physical Distributioin and Materials Management*, 2nd Ed. New York: Ronald Press.

Hill, S. (2010). Regional considerations on managing Ggobal logistics. *95th ISM Annual International Supply Management Conference*.

Lin, L. and C. Hong (2006). Operational performance evaluation of international major airports: An application of data envelopment analysis. *Journal of Air Transport Management* 12(6), 342-351.

Rodrigues, A.M.,Bowersox, D.J. and Calatnoe, R.J. (2005). Estimation of global and national logistics expenditures: 2002 data update. *Journal of Business Logistics* 26(2), 1.

The World Bank (2007). http://data.worldbank.org/ <Retrieved January 2011>

A REFERENCE MODEL FOR LOGISTICS OF OFFSHORE WIND FARMS - A LIFE-CYCLE-ORIENTED APPROACH

Nina Vojdani, Felix Lootz
University of Rostock, Chair of Production Organization and Logistics

ABSTRACT
The federal government of Germany formulated its energy plan guidelines for an environmentally friendly, reliable and affordable supply of energy and defines renewable energy as the cornerstone of future energy provision. To achieve this objective, offshore wind farms are becoming increasingly important. However, to date, no research has established the optimization of offshore wind farm logistics from a life-cycle-perspective. Therefore, the purpose of this study is to present a life-cycle-oriented reference model of the value chain and logistics functions of offshore wind farms. The model allows the structuring of necessary logistics activities and proposes approaches to optimize the logistics of offshore wind farms. Some approaches found are: (1) combination of offshore and onshore supply warehouses, (2) integration of supply and distribution logistics for equipment manufacturers and parts suppliers, (3) supplier and manufacturer parks, and (4) outsourcing logistics function to specialized service providers.

Keywords:
Offshore Wind Farms, Maritime Logistics, Offshore Logistics, MRO Logistics

INTRODUCTION

The federal government of Germany has formulated its energy plan guidelines for an environmentally friendly, reliable and affordable supply of energy and defines renewable energy as the cornerstone of future energy provision. The government is expected to publicly fund the wind power generation at sea as it aims to increase capacity to an ambitious 25 GW – approximately 4,000 offshore wind turbines - by 2030 from less than 0.5 GW in the fiscal 2010, as it was stipulated in the strategy on marine wind energy utilization in 2002 [1]. The Fukushima No. 1 nuclear disaster is expected to further boost the public and political support for the wind energy sector.

Currently, more than six percent of the German electricity demand is covered by wind energy [2]. Until the end of 2010, over 20,000 onshore wind turbines have been installed in Germany. Although wind power plant output is far below total electricity demand, the potential of wind energy is not exhausted. In particular, the replacement of older equipment with modern, more efficient turbines ("repowering") and the use of wind energy at sea offer prospects for further expansion. Figure 1 shows planned and approved offshore wind farms in the North and Baltic Sea.

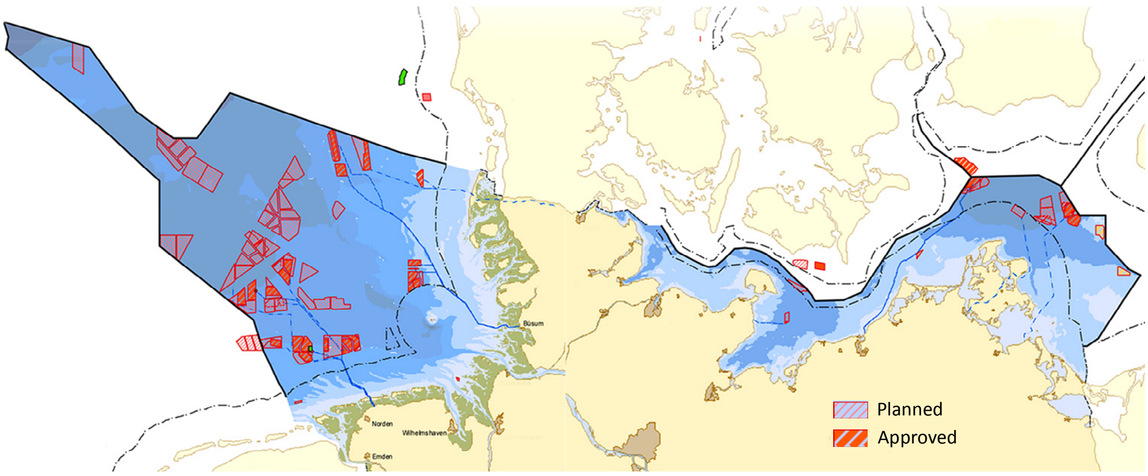


Figure 1: Planned and approved offshore wind farms in the North and Baltic Sea [cf. 3]

Compared to countries such as Denmark or Sweden almost all sites in Germany are installed in relatively large water depths (> 20 meters) and with long distances from the coast (> 30 kilometers). The reasons are the intensive use of the German coastal waters by shipping, as a training area for Navy and Air Force, and as fishing areas. The site conditions cause significant technical and economic uncertainties. Water depths of up to 40 meters, long distances to the coast, and strong physical stress caused by wind, waves, and salty air make high demands on foundations, encapsulation of cables and used materials [3].

The share of logistics costs of an offshore wind farm is estimated at 15 percent [4]. But unlike other industries, logistics costs transparency is barely given. While absolute figures remain unclear, the costs raise with increasing distance to the offshore job sites along with increasing component dimensions and weights. Besides costs of heavy duty transportation, costs of resource-intensive handling and storage processes along the transport chain are also relevant. Ports must provide heavy duty capable storage area and cranes must be adequately designed to handle offshore wind turbine components.

From a perspective of operators and service providers, there are no particular experiences in areas such as logistics planning and design of the entire transport chain, the appropriate organization of transportation, installation vessels, as well as service teams, and the definition of necessary infra- and superstructure in ports. First reference projects have highlighted weaknesses, risks, and the need for detailed studies. Unresolved issues especially in the areas of sea- and land-based transport, pre-assembly in ports, maritime assembly, operation, repowering, disposal, and integrated logistics concepts have emerged to this day. The trend to more efficient wind turbines and growing wind farms exacerbates the situation significantly.

Current logistics research focuses mainly on concepts and methods to design, plan, and control logistics activities for offshore installation and maintenance of wind farms. Scholz-Reiter et al. examined basic conditions and existing disturbances of supply chains for offshore installation and developed a mathematical model using mixed-integer linear programming to calculate the optimal installation schedule for offshore wind farms [5]. Lindqvist and Lundin have modelled spare part logistics for wind turbines, eximaned different strategies for supply and storage of spare parts, and compared the profitability [6]. However, to date, no research has established the optimization of offshore wind farm logistics from a life-cycle-perspective.

Therefore, the purpose of this study is to present a life-cycle-oriented reference model of the value chain and logistics functions of offshore wind farms. The model is targeted to support the structuring of necessary logistics activities and to propose approaches to optimize logistics of offshore wind farms.

The value chain and logistics processes of German wind farms installed in the North and Baltic Sea were investigated for this paper. Field studies, literature studies and expert panels were undertaken to develop the life-cycle-oriented approach to logistics optimization. The structure of the paper is as follows. In the next section the main processes from planning to dismantling of offshore wind farms are characterized. In the subsequent section the main process from a life-cycle-perspective are described and a reference model for the value chain and the associated logistics function of offshore wind farms is illustrated. Additionally, necessary logistics activities within the process steps are structured and potential optimization approaches are provided. In the last section, conclusions are presented and fields for future research are identified.

FROM R&D TO DISMANTLING OF OFFSHORE WIND FARMS

In a case study of the POWER-Project [7], experiences and lessons learned from the project planning and implementation of eight European offshore wind farms were collected and assessed. The results show that project planning and implementation of offshore wind farms are very different from those of onshore wind farms. The planning processes of offshore wind farms are extremely complex. The conducted field studies and expert panels have shown that planning of procurement, installation, commissioning, and operation set high expectations for all involved parties. Every single wind farm project necessitates preparation stage activities such as pre-feasibility-studies, strategy development, and the definition of project structure.

The next stage is characterized by a detailed project planning. The planning activities cover approval processes, site inspections, the definition of the functional requirements regarding the implementation processes, tendering procedures, as well as financing and insurance agreement negotiations. All activities result in a master plan, in which the overall project development concept is comprehensively drafted and described. The planning stage finalizes with the placing of orders.

Within the following stage, the implementation starts with the engineering and procurement of components, production outgoing inspection, pre-tests, training of installers, and distribution of manufactured components. The relevant components are towers, generators, nacelles, blades, foundation structures, and submarine cables.

The next stage is characterized by the construction and commissioning of the offshore wind farm. This stage includes the pre-assembly of components in seaports, maritime transport to the job sites, construction of submarine foundation structures, assembly of wind turbines, as well as installation of onshore and offshore electronics. This stage ends with a test run of the entire offshore wind farm. If the test performed well, the wind farm is prepared to go-live and operate for about 25 years. During operations, each turbine is constantly monitored by a so-called SCADA-System (Supervisory Control and Data Acquisition) and maintained according to component's conditions. The turbine can also be replaced by new and more efficient wind turbines within the repowering stage. In the last stage, the wind turbines are dismantled and disposed.

VALUE CHAIN AND LOGISTICS FUNCTIONS OF OFFSHORE WIND FARMS

Although the planning processes are necessary for the installation and operation of offshore wind farms, this paper focuses on the processes of the implementation stages. Each step of the implementation stages can be systemized according to the turbine's life-cycle, Figure 2. All steps are also seen as processes and activities that are part of the value chain of an offshore wind farm. The amount of value being added differs significantly in each step. In the following, the logistics functions are structured depending on the value chain processes and optimization approaches are given.

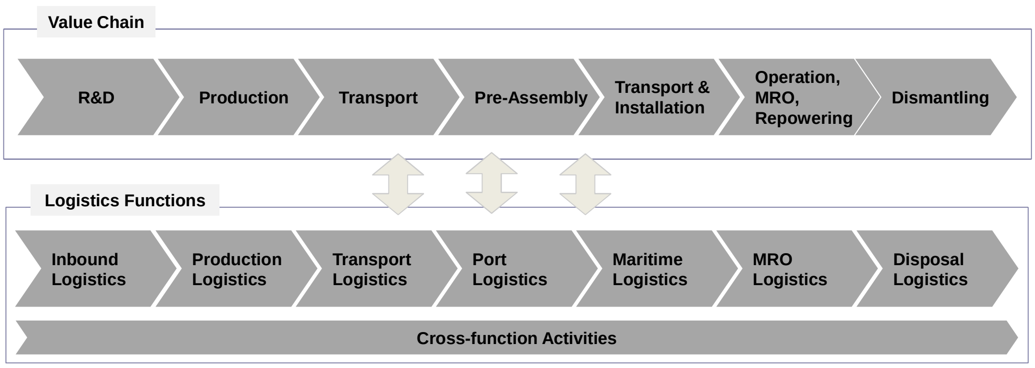


Figure 2: Reference Model for the value chain and logistics functions of offshore wind farms

The value chain starts as described above with the engineering of relevant components (Research & Development). From a logistics standpoint, there are no logistics processes involved within this step, but as far as the life-cycle is concerned, engineering of components meetings logistics requirements will have enormous impact on the overall share of logistics costs. For example, engineering rotor blades in accordance to the means of transport will result in less transportation costs, since two or three blades may be transported at one time. Cost savings in regard to transport, handling, and storage can be realized if engineered suspension points and handling devices ("jigs") meet logistics requirements of the entire supply chain.

Inbound logistics & Production logistics

The next step of the value chain is the production of wind turbine components, foundation structures, and submarine cables, whereas this paper focuses on wind turbines. In a few years, the wind turbine manufacturer derived from small engineering companies to global corporations. As the wind energy business sector gains increasing attraction, more competitors will try to enter the business. Simultaneously, the demanded output of wind turbines grows disproportionately due to an increased number of planned and approved offshore wind farms. Therefore, wind turbine manufacturer are faced to develop more efficient production strategies and to rethink non core operational functions like procurement and logistics in order to gain competitive advantages.

Generally, the logistics of manufactures can be differentiated into inbound, production, and outbound logistics. Inbound logistics include among other things supplier management (contracting, rating, billing, audits, development etc.), inventory management (inventory control, VMI etc.), warehouse operations (incoming goods inspection, storage, consolidation, kitting, packaging, outgoing goods etc.), document management, order management, and customs clearance. Inbound logistics can be seen as part of procurement processes.

Production logistics involves all logistics activities directly and indirectly supporting the production processes. These are order management at the production line (order processing, material requests, shipment orders, hot parts delivery etc.), line feeding, kitting, empties handling, waste disposal, buffer management, shuttling, definition of transport and storage jigs, as well as pre-assembly or sequencing. Outbound logistics can be seen as the transport logistics and will be discussed in the next chapter.

The production processes of wind turbines are characterized by series production of a few standardized turbine types. The turbines only differ in their dimensions and power generation performance. These basic conditions are suitable to apply lean principles to the production processes. The principles include pull, zero defects, flow, and cycle-times. The implementation of lean techniques results in eliminated waste throughout the operational processes. Manufacturers can also attempt to achieve a higher productivity through reducing the vertical range of manufacture. In this context, suppliers are becoming more important as strategic partners within the supply chain. As experiences in the automotive industry - a leading industry concerning high productivity - have shown, the cooperation of manufacturers and supplier can be organized as either manufacture or supplier parks or as international production networks. The parks are characterized by central production facilities, realizing high saving of transportation costs. Within production networks, manufacturers make use of low labor costs in developing countries for labor-intensive work. Final assembly or finishing can be performed at the manufactures' facilities while maintaining the control over the quality. With increasing transportation costs, it is recommendable to establish manufacturer and supplier parks at the seaports and close to the quays. The avoidance of use of secondary construction facilities at the ports can be beneficial to reduce costs associated with the handling, storage, and transport of individual components. The logistics activities must be adapted accordingly (introduction of KANBAN, Just-in-time-delivery etc.). For example, the inbound logistics of manufacturer and distribution logistics of parts supplier should be integrated and coordinated. Another approach to reduce costs is the use of combined warehouses for the supply and distribution of components and spare parts as well as tools. This strategy will be discussed in connection with MRO logistics.

Transport logistics

Between production and harbour handling, produced components are transported land-based and by specialised heavy duty vehicles. The logistics processes consist of transport planning and transport execution. Within planning, the selection, availability check, and scheduling of transportation for heavy duty materials, transport equipment, means of securing (fittings, protective foil etc.), personnel, and logistics service provider (carrier) is done. It also includes route planning, arrangements on road enclosures, capacity planning, transport mode optimization, and trip operations. The transport execution is the actual heavy duty transport. It can be recommended to use specialised logistics service provider to ensure carriers compliance to customer service level through selection, auditing, contracting, and training of carriers using specialist market knowledge and intelligence. Outsourcing to a service provider enables the combining of activities to perform transport services by closely monitoring carriers´ performance against plan and manage exceptions and contingencies to minimize risk of disruption in the transport flow. Additionally, manufacturer can receive the optimum network for executing all transportation activities. According to [5], shipments should be performed overnight when infrastructure can be used exclusively. The ideal optimization approach is to completely eliminate the necessary transport activities through establishing production facilities in seaports and storing components directly at the loading quay.

Port Logistics

Ports are crucial junctions as the interface between land-based work and offshore constructions. In particular, ports must meet as a prerequisite for the construction of wind farms the requirements of the offshore wind energy. In the past, plans for offshore wind farms underestimated the size of the necessary area for storage and pre-assembly in seaports per wind turbine. In general, for the pre-assembly of an offshore wind turbine an area of 1,000 square meters per wind turbine is required [7]. Simultaneously, it is critical to avoid out-of-stock situations. Missing parts at the port will cause significant delays of the transport process leading to extensive time lags of the entire installation process up to several months. It also causes additional costs concerning chartering fees of up to 250,000 € per installation vessel and day. The ports logistics has the following tasks: determination of required infrastructure (seaport, storage capacity, quay capacity etc.), determination and scheduling of required superstructure like handling equipment, materials handling, and storage equipment. It also has to plan, execute, and control pre-assembly processes. As mentioned above, an ideal solution would be to pre-assemble wind turbines as much possible at the seaports directly from manufacturer’s premises. Important to the economics of offshore wind farms is the avoidance of offshore work because labor costs in the factory act to those of the port or at sea on a 1:3:5-10 scale [7]. Offshore work can also be avoided through detailed testing before mass production.

Maritime Logistics

The maritime transportation and construction of wind turbine components is highly controlled by meteorological influences. Weather conditions determine the possibility of the transportation and construction of components and underwater energy cable networks. Different wind analyses have shown that only about 120-200 days a year can be used for the installation of offshore wind farms [3, 4]. Thus, it is important to comply with the existing time windows for transport and installation through robust planning and continuously monitoring of the weather conditions [5]. According to [4], the assembly of wind turbines on different foundation types (monopiles, tripods etc.) involves a number of operations which require great precision and stability. Keeping the number of offshore operations to a minimum is desirable concerning the existing time windows as well as transport and construction costs. However, the optimum solution lies somewhere between installation of a largely pre-assembled turbine and offshore assembly of a large number of smaller components. The main constraints are: available deck space, lift capacity of the vessel cranes, and manufacturer’s requirements of the assembly sequence. Vessels for transport, installation and supporting activities are a key element of the transport chain of offshore wind farms representing a significant cost factor [4]. Using up to 60 different types of vessels for the implementation processes of one wind farm is not atypical.

In general, the logistics processes consist of maritime transport planning and maritime transport execution. Within planning, the selection, availability check, and scheduling of maritime transportation for heavy duty materials (jackup platforms, vessel etc.), transport equipment, means of securing (fittings, protective foil etc.), crew and technicians, feedering services, and logistics service provider (carrier) is done. It also includes route planning, capacity planning, weather monitoring, and coordination with certification companies (warranty surveyor). The execution covers trip operations and maritime heavy-duty (bulk) transport.

Since the implementation of offshore wind farms highly depends on weather conditions and vessel availability, the maritime logistics processes must be seen as the bottle necks of the supply chains. The planning of holistic offshore transport chains should therefore consider these possible disturbances.

MRO Logistics

Maintenance, repair and overhaul (MRO) of wind turbines are characterized as difficult, resource-intensive, and expensive processes. A quarter of the total cost of an investment accounts for maintenance and repair. A cost-efficient service support of wind turbines requires well-coordinated MRO organizations and optimal MRO strategies including handling and storage. Since most parts of the turbines are crucial for the functionality of the turbine, the parts must be monitored in order to identify defect parts and to pro-active exchange faulty parts.

The commercial activities of MRO logistics include among other things warehouse operations of new and refurbished components (incoming goods inspection, storage, consolidation, kitting, packaging, outgoing goods etc.), refurbishing used components, condition monitoring, spare part management (procurement, planning and forecasting, distribution etc.), planning and operation of distribution centres, inventory management, handling of repair, change, return, and disposal management, claims management, incident management, planning and coordination of maintenance processes (scheduling installation vessels and qualified personal), as well as component delivery to job sites.

According to Lindqvist & Lundin large power wind farm systems, including a number of wind farms with the same wind turbine types, propose pooling of spare parts at it is much more cost-efficient compared to local storage and individual handling [6]. Furthermore, a central warehouse should be used for reordering and storage of critical spare parts, such as gearboxes, generators, and blades as it is more profitable. As shown in Figure 3, the manufacturer and supplier deliver spare parts to a central warehouse. The warehouse must store approximately 10,000 different parts for on- and offshore wind farms. Parts differ from generators and large components to small parts and consumables as one wind turbine consists of more than 2.500 different parts. IT-based spare part strategies should be used to reorder spare parts from manufacturer and supplier. Orders of technicians can be shipped to local hubs by trucks or, in urgent cases, by airfreight. The hubs maintain a majority of the main parts, which may be delivered within a few hours by courier or express services to the technicians at the job site (on- and offshore) or port (offshore).

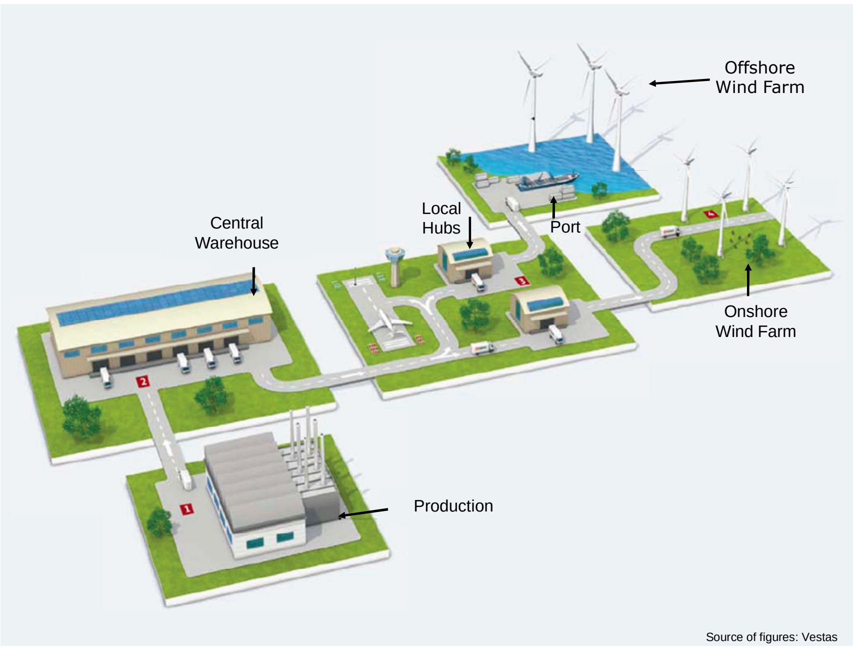


Figure 3: MRO Supply Chain integrating supply of on- and offshore wind farms [cf. 8]

In addition to the spare parts, the necessary tools and lifting equipment in a calibrated and tested state can be requested and supplied from the hubs. As discussed above, another approach to reduce costs is the use of combined warehouses for the supply and distribution of components and spare parts as well as tools. This strategy aims to store all relevant parts, components, and tools within one warehouse (central or local), which is closely located to the manufacturers and suppliers. This strategy can reduce inventory costs significantly.

Disposal Logistics

The life-cycle of an offshore wind turbine ends after supposedly 25 years with the dismantling of the wind farm. The logistics processes will most likely include return management, asset recovery, organization of repowering processes and selection of recycling and dismantling sites. Generally, the processes from the construction activities can be applied reversely for the disposal logistics. According to the state-of-the-art there are no concepts for the logistics of dismantling offshore wind farms.

Cross-function Activities

Cross-function activities can be seen as processes or tasks, which can be applied to the entire life-cycle or are supportive for the operational and logistics processes. The activities include sophisticated project, contract, and interface management, since a lot of actors are involved at each step of the value chain. Further more monitoring and KPI reporting can ensure compliance with agreed project targets and service levels. Using process visibility and IT-platforms can increase overall transparency. More over, turbine and parts documentary, continuous improvements, quality control, certification management, and fleet management are possible activities.

With manufacturers and wind farm operators increasingly focusing on core competencies, the outsourcing of logistics activities to specialized logistics service provider becomes more important. Advantages are the access to existing transport networks and logistics know-how. Inventory costs can be reduced through multi-client-warehousing, meaning warehouse operators manage parts and components for several wind farms, turbines types, manufacturers, and suppliers. The operators provide warehouse infrastructure and standardized processes and transparency, reducing the costs of storage and inventory. Further more, using over night services, package shipments, express, and hot parts delivery can increase the availability of wind turbines and production capacities. In terms of planning and design of supply chain networks the cooperation with experienced logistics service provider and the collaboration of manufactures with suppliers can ensure efficient offshore supply chain management. Additionally, a professional transfer of operators or manufacturers employees to service provider enables the achievement of labour cost savings and higher operations efficiency.

CONCLUSION

As the wind energy sector gains increasing importance and the planned expansion of offshore wind turbines is further progressed, the growth and optimization potential of logistics must be noted. Therefore, the aim of this paper was to develop a practical reference model of the value chain and logistics functions of offshore wind farms. The findings show detailed processes from the production to disposal of offshore wind farms. From a life-cycle-perspective, production, pre-assembly, maritime transportation, construction, and maintenance are key elements of the value chain and most demanding in terms of logistics requirements. These elements offer significant economic potential, which should be exploited by the operators and actors involved. The paper also establishes fields of logistics activities, which can be adopted by the actors involved in the production, transportation, installation, and operation processes of offshore and onshore wind farms. Approaches proposed are the combination of offshore and onshore supply warehouses, integration of the supply and distribution logistics for equipment manufacturers and parts suppliers, supplier and manufacturer parks, collaborative planning and design of supply chain networks, and outsourcing logistics processes to specialized service provider.

The findings support actors to capture the value proposition and benefits of effective and efficient offshore supply chain management. The model can be used to further develop methods to evaluate the potential impact of efficient logistics on the life-cycle-costs of wind farms. Furthermore, the model is beneficial to increase system availability, exploit synergies, reduce costs, and meet the high expectations of return. Whilst the approach is holistic and applicable, the available data were limited to German wind farms, and therefore not sufficient to fully generalize the possible impact of the recommended optimization approaches. Logistics concepts from other industries should be further investigated and tested for transferability in the wind energy industry.

REFERENCES

[1] BMU et al.: *Strategie der Bundesregierung zur Windenergienutzung auf See*. 2002

[2] Agentur für Erneuerbare Energien: *Der Strommix in Deutschland im Jahr 2010*. accessed on 14/05/2011 from http://www.unendlich-viel-energie.de/uploads/media/AEE_Strommix-Deutschland-2010_feb11.pdf

[3] Schumann, B.: *Logistische Herausforderungen bei dem Bau eines Offshore-Windparks in der deutschen Ostsee*. In: 10. Rostocker Logistik Forum. Publisher: Nina Vojdani. p. 89-93. 2010

[4] GL Garrad Hassan: *Analysis of Capabilities of Harbours in Mecklenburg-Vorpommern and Assessment of Opportunities from Offshore Wind Development*. Final Report. 2011

[5] Scholz-Reiter, B.; Heger, J.; Lütjen, M.; Schweizer, A.: *A MILP for installation scheduling of offshore wind farms*. In: International Journal of Mathematical Models and Methods in Applied Science. 2(5): 371-378. 2011

[6] Lindqvist, M.; Lundin, J.: *Spare Part Logistics and Optimization for Wind Turbines*. Methods for Cost-Effective Supply and Storage. Report. Uppsala University. 2010

[7] Gerdes, G.; Tiedemann, A.; Zeelenberg, S.: *Europäische Offshore-Windparks - Eine Untersuchung der Erkenntnisse und Erfahrungen von Offshore-Windpark-Projektentwicklern*. Management Summary. 2010

[8] Vestas: *Outsourcing der Servicelogistik – Königsweg oder Sackgasse?*. Presentation. WindLog. 27.05.2010

A STUDY OF THE DEVELOPMENT AND APPLICABILITY OF THE A|D|S 21ST CENTURY SUPPLY CHAINS (SC21) INITIATIVE

Stephen A Morgan MBA MSc CMC MIC CEng MIET
Pauline A. Found FIOM, PhD, MBA

The Lean Enterprise Research Centre, Cardiff Business School, Cardiff University

INTRODUCTION AND CONTEXT

This paper, an abridgement of an MBA research project, describes a study of the development and applicability of the Aerospace Defence Security (A|D|S) 21st century Supply Chains (SC21) initiative (A|D|S 2010b) within the context of the UK Ministry of Defence (MOD) and its supply chain.

The Defence Industrial Strategy (DIS) (MOD 2005) outlined the need for better and where appropriate, longer term MOD relationships with key suppliers. The greater use of competed partnering arrangements underpinned by openness and transparency was identified as key to future relationships with industry, although the ethos and associated behaviours were espoused as being applicable to any form of contractual arrangement. The strategy detailed a vision of a much more open relationship with industry, based on mutual understanding, managing tensions and differences, sharing information, codes of practice and behaviour and mechanisms for the resolution of problems. The stated intention was to increase emphasis on joint team behaviours, making relationship management part of core acquisition business and incorporating partnering behaviours within supplier selection decisions. From an internal MOD perspective the strategy involved greater flexibility and a move to contracting for capability availability as well as focusing on Through Life Capability Management, all of which require long term relationships to be developed with industry. The DIS has shaped MOD supply chain policy since 2005.

Internal MOD research had also revealed a need to consider the MOD's approach to supply chain quality assurance. SC21 appeared to offer a solution to both requirements and although a significant body of supply chain related literature was in existence, there was a gap relating to the MOD and its supply chain.

The research established that SC21, UK defence industry best practise, is applied in a limited way within the MOD. The paper offers a strategic way ahead complimentary to DIS and shows that full implementation of SC21 would align and integrate the MOD with its supply chain. Developing a value chain approach, through committed application of SC21 internally and externally, would accrue significant benefit for the MOD in terms of effectiveness, efficiency, quality and innovation, including the reduction of direct MOD quality assurance. The paper outlines the initiative and discusses and analyses the research findings. It takes into account the benefits experienced by UK defence companies and consequent implications for the MOD processes for addressing quality, efficiency and effectiveness in the supply chain, considering current MOD practise against the potential benefit to be gained by the MOD fully applying the SC21 approach.

LITERATURE REVIEW SUMMARY

The supply chain, value chain and supplier development literature is dominated by the US auto industry and its relationship with the Japanese auto industry. Whilst these areas have characteristics linked to the UK defence industry, there are also significant differences in terms of volume, numbers of standardised products and levels of interface with the end customer. There are a limited number of papers relating to the aerospace sector, which have closer parallels to the UK defence industry and a smaller number of connected defence industry based papers. Commentators agree on the need to develop supply chain relationships and the trend to inter value stream rather than inter firm competition, as well as the complexity of dealing with the relationship issues of equity, trust and power balances within a supply chain. There is guidance on the concepts to be considered when developing supply chains and judging the benefits to be gained, but it is not directly linked or entirely relevant to the UK defence environment.

In order to bridge the resultant gap and add to the knowledge base, the resultant study methodology enabled the review of efforts with the UK defence sector to generate a supplier and supply chain development programme, the A|D|S SC21 initiative.

RESEARCH BACKGROUND AND QUESTIONS

A|D|S is a trade organisation representing the UK aerospace, defence and security industries (A|D|S 2010a), it was formed from the merger of a number of smaller sector specific organisations, including the Defence Manufacturers Association (DMA) and the Society of British Aerospace Companies (SBAC). The MOD is a key customer of the sectors that A|D|S represents. A|D|S oversees the SC21 programme (A|D|S 2010b) which aims to improve competitiveness within the industries it represents. SC21 is essentially a change programme designed to rapidly improve the competitiveness of the defence and aerospace sectors through dramatically improved supply chain performance. The need to consider methods to improve MOD supply chain quality assurance methodology and the DIS requirement to develop supply chain relationships appeared to be met by the A|D|S SC21 initiative.

An initial literature review identified the main gaps in the literature that raised questions meriting further research. Although there is a considerable volume of literature relating to supply chain management, supplier development and supplier relationships, work relating specifically to the combination of all three areas addressing the situation with respect to the MOD as a major intelligent customer and its supply chain wasn't readily apparent. The main research question addressed is:

"Would the SC21 initiative if fully applied within the MOD benefit quality, effectiveness or efficiency?"

The primary question raised two subsidiary research questions:

"Why should the MOD embrace the A|D|S 21st Century Supply Chains (SC21) initiative?"

And

"What would be the benefits to the MOD of embracing the A|D|S 21st Century Supply Chains (SC21) initiative?"

This paper reports the research findings that sought to determine answers to the research questions raised and to inform and develop policy for the MOD.

RESEARCH METHOD

The benefits experienced by SC21 member companies and the potential benefits to the MOD were considered, based on a critical realist, deductive approach. The study focused on SC21 and its link with the MOD. It reviewed the relevant literature as well as benefits experienced by SC21 member companies and the potential benefits to the MOD, through secondary information gained by publicly available case study and related information, as well as primary data gained from industry and the MOD through a detailed case study, questionnaires and semi structured interviews.

The study addressed the structure and development of SC21, its membership, its aims and its relevance to defence, as well as its potential for addressing quality in the MOD's supply chain. The use of detailed case studies, primary data from questionnaires and semi structured interviews enabled a detailed view of the application of SC21, its benefits and issues to be captured. The use of secondary case study and survey data confirmed and broadened the primary data findings, enabling the analysis of the data to be more generalisable to the wider defence industry, rather than just the companies involved in primary data collection.

FINDINGS

Up to 80% of cost lies in the upstream supply chain, along with delivery and lead time problems. The MOD as an integral part of an SC21 based supply chain therefore has the potential to achieve considerable tangible and intangible benefits from developing a supply chain to SC21 award level standards. The findings support the assertion in the literature that supply chain management is a key element of controlling cost, maintaining quality and ensuring on time delivery to customers.

Research showed that the application of SC21 enables supply chain improvement both to achieve those aims and to measure their efficacy. A fragmented, wasteful and innovation lacking UK defence industry was seen to be in need of the introduction of lean efficiency through supplier support and cooperation, for which SC21 was conceived to provide. By using SC21 to align underlying improvement tools and techniques, defence industry prime contractors have: gained competitive advantage from, given strategic direction to and introduced relationship management into, their supply chains. A very complex supply chain exists within the UK defence industry and although SC21 has begun to introduce order and improvement, achieving a great deal since its 2006 inception, much remains to be done.

The importance of customers being an integral part of supply chain improvement was established, as was the fact that the MOD is lacking in its internal application of SC21 principles and that its support to SC21 in the supply chain whilst initially positive, now requires reinvigoration. Increasingly major MOD contracts are for the provision of services and capability availability in line with the DIS, which directly involves MOD staff in the supply chain. It was shown that due to the importance of working directly with key suppliers across tiered supply chains to realise synergetic improvement benefits, the MOD needs to revaluate its approach. This means including the end customer in a value rather than supply chain outlook, with the intervening MOD acquisition and support Joint Project Teams in effect being an additional tier in that chain. This approach would enable value perceptions and delivery to be optimised across organisational boundaries.

Research showed that SC21 metrics are currently applied at supplier level, but not across the whole supply chain and that as the whole supply chain delivers the MOD's capability, that the SC21 metrics should also be applied at the higher and overall, prime manufacturer or value chain level. The use of lean was recognised as consistent with SC21, as was the importance of establishing a learning and continuous improvement culture based on top level management engagement, strategic intent and organisational structure. Industry reported enjoying success through these means, supported by SC21, however MOD responses indicated a lack of a structured approach to and leadership engagement with continuous improvement, consistent with a typical (i.e. non sustainable), rather than sustainable organisation (Hines et al 2008). Lean aligned with Six Sigma (LSS), was shown to be effective in addressing continuous improvement across large and complex organisations, with prime contractors and the DoD in particular providing a very effective model of its application: "DoD leadership understands that Lean Six Sigma can help it do more with its fixed budget" (DoD 2008). PowerSteering software, already used by the MOD to track benefit realisation, is a key enabler of the DoD programme, although it is more widely utilised than in the MOD and in a similar way to UK defence suppliers, for example in the prioritisation of improvement projects. Slone et al's (2010) key areas for supply chain development (Table 1) underline these conclusions.

Key areas for supply chain development.
• Supply chain personnel in terms of leadership and team members with appropriate training and experience.
• Maintaining oversight and implementation of supply chain technology and trends (noting that software itself doesn't produce process improvement, but supports its implementation).

• Elimination of cross functional disconnects.
• Collaborate with suppliers and customers.
• Utilise a disciplined project and change management process.

Table 1 Five key areas for consideration in supply chain development (Slone et al. 2010).

Common standards, metrics and a consistent approach, enabled by SC21 are an effective basis for supplier improvement and development, but SC21 does not currently consider overall supply or value chain improvement. Criticism of the application of lean in the service sector (Seddon 2003 and 2008) has accurately recognised that improvement tools should only be used when the system's purpose, conditions and required outputs are understood, this "systems thinking" technique is appropriate within an MOD and SC21 context. Equity, power and trust are important relationship elements to be considered within a supply chain. SC21 includes the ability to measure these aspects of relationships and therefore allows supply chains to work to resolve conflict, drive appropriate behaviours and build long term relationships based on trust, with the consequence of reducing the effects of misuse of power and engendering equitability. However, the lack of visibility of the effectiveness of the prime contractors' own improvement programmes is seen as an issue which needs to be resolved and impacts equitability with lower supply chain tiers. The SC21 initiative also needs more exposure within prime contractors, the wider defence industry and the MOD.

Network sourcing through supplier associations was recognised as a key process supporting competitive advantage; it was established that SC21 tools could be used in the context of whole supply chain development to drive towards network development. However, whilst the initiative enables this to happen informally, it does not at present explicitly identify its achievement in the manner described by Hines (1995 and 1996) as an objective.

Prime contractor assessments of Small to Medium Enterprises (SMEs) have been consolidated using a group approach under SC21. This has resulted in standardised techniques and a consequent reduction of the duplication of assessment effort, benefiting primes and lower tier companies alike, reducing overhead and freeing resource to meet direct output requirements. Underpinned by NADCAP (ADS 2010c), AS9100 and the underlying OASIS database system (ADS 2010d), this approach could significantly benefit the MOD across the supply chain (although these aerospace originated underpinning processes and standards need to be fully extended across the land and maritime sectors). If SC21 is enabling effective quality assurance, then the MOD's requirement to conduct it can be reduced or removed, cutting contracting and manpower costs, whilst providing the MOD with more robust cost and sustainability assurance and wider management information.

Benchmarking is a key method of monitoring performance; products, services and practises are continuously measured against sector leaders and close competitors. SC21 enables benchmarking, not only against comparator companies within the scheme, but also against world class supply chain standards. However, it currently lacks service measures, the SERVQUAL tool (Parasuraman et al, 1985; 1988, cited in Ward and Graves (2006, p. 28)) used to measure customer satisfaction without a tangible product, is potentially an assessment methodology for MOD service and availability contracts.

A detailed case study identified that using SC21 enabled theoretical value chain benefits for an individual supplier, as well as the overall supply chain and the end customer. SC21 accreditation was identified by the case company as a strategic objective to gain a market leadership position in the defence and aerospace sector. Accreditation required exacting standards of delivery and performance, improved customer relations and the successful completion of independent assessments against the EFQM and a lean manufacturing audit. As well as a direct tangible efficiency benefit, the company also gained an intangible benefit in the form of increased brand value and therefore future profit potential. The case illustrated a framework around which SC21 could be introduced, the importance of including the customer in improvement and that its deployment can deliver real business benefit for an individual company as well as the overall value chain.

From the prime contractor and MOD perspective SC21 benefits have been limited to date, but primes anticipate that significant benefits will accrue as the initiative matures and supplier take up increases. The MOD currently does not use SC21 metrics to assess the supply chain and therefore has difficulty in assessing its benefit, although replacing current MOD supplier assessments with SC21 metrics at the prime or value chain level would allow benefit appraisal. As the ultimate beneficiary of supply chain improvements, the MOD is likely to enjoy overall benefits of reduced cost, improved quality and on time delivery through applying and supporting SC21; key benefits are highlighted at Table 2.

SC21 Key improvement and development benefits summary
Overall • Efficiency and Effectiveness. • Focus on improvement. • Lower supply chain tiers show a more productive approach to continuous improvement as a consequence of a unified approach, reducing MOD resource expenditure on supplier development. • Requiring SC21 accreditation from lower tier suppliers increases the effectiveness of the UK supply chain and emphasises development of capability supported by prime contractors. • Greater supplier leverage through customer visibility of lower supply chain tiers. • Cross MOD - industry team working and process rationalisation. • Long term planning between MOD and suppliers. • Improved pull through of innovation from the supplier base. • Reduced risk in the supply chain through the use of SC21 award holding suppliers.
Quality Cost Delivery • Improved quality levels are a benefit perceived by both customer and supplier. • Quality cost reduction through the reduced cost of scrap, rework, dispatch (re-delivery) and failure demand. • Better on time delivery performance. • Reduced lead times. • Reduced number of overdue/backlog orders. • Less customer (Armed Forces end user) complaints. • Reduced costs through increased standardisation.

SC21 Key improvement and development benefits summary
Business Benefits • Programming Improvement. • Better contract management. • Consistent forecasting. • Increased return on capital employed. • Reduced inventory and consequential increase in working capital. • Better cash flow. • Greater focus on "fit for purpose" equipment. • Sustainable World class performance. • Environmental and Corporate Social Responsibility improvements, enhancing the MOD's reputation. • Genuine and positive enterprise wide culture change to sustainable continuous improvement. • An engaged and motivated workforce.

Table 2: Key improvement and development benefits identified through primary and secondary research likely to accrue to the MOD through the application of SC21 (Author).

RESEARCH IMPLICATIONS

This paper adds to the body of knowledge on taking a value chain approach to supply chain management. The empirical evidence shows that there is a positive outcome with respect to quality, innovation, efficiency and effectiveness. The findings of the research have general applicability beyond the MOD and can be replicated in other supply chains.

The paper has prompted the MOD to review and reinvigorate its engagement with the A|D|S SC21 initiative, although not to instigate a full policy deployment of a Continuous Improvement programme. Further research is needed to assess the accrual of benefits as SC21 matures, the effects of an MOD contract let against SC21 principles and the implications of SC21 for SMEs in input and output terms.

CONCLUSIONS

The answer to the subsidiary question, "Why should the MOD embrace the A|D|S 21st Century Supply Chains (SC21) initiative?" is that by fully embracing SC21 and applying it internally as well as actively supporting its use within the defence industry, the MOD would be able to transform its performance and relationship with industry and play a fully effective and integral part in its supply chain as the UK defence industry's key customer.

The second subsidiary question, *"What would be the benefits to the MOD of embracing the A|D|S 21st Century Supply Chains (SC21) initiative?"* is addressed by Table 2. Answers to both these questions provide evidence that the SC21 initiative, if fully applied within the MOD, would benefit quality, effectiveness and efficiency, which answers the overarching research question.

In conclusion the MOD can only gain from being part of a more efficient supply chain where suppliers at all level are competitive, low-cost and responsive and where good communications and relationships are the norm. Achieving this platform through embracing the SC21 initiative would allow the MOD to further develop along with SC21 participants as part of a UK defence industry value chain, founded on a fully networked supplier association base, delivering value across organisational boundaries. By fully applying the A|D|S SC21 initiative, the MOD would benefit in terms of improved quality, effectiveness and efficiency and the reduction of direct MOD quality assurance, as well as enhancing innovation in the supply chain.

REFERENCES

A|D|S. 2010a. *Home Page* [Online]. Available at: http://www.adsgroup.org.uk/ [accessed 1 September 2010].

A|D|S. 2010b. *21st Century Supply Chains (SC21)* [Online]. Available at: http://www.sbac.co.uk/pages/80338686.asp [accessed 3 September 2010].

A|D|S. 2010c. *Guide to NADCAP* [Online]. Available at: http://www.sbac.co.uk/pages/08044070.asp [accessed 10 October 2010].

A|D|S. 2010d. *Guide to AS/EN9100* [Online]. Available at: http://www.adsgroup.org.uk/pages/08567446.asp [accessed 10 October 2010].

DoD. 2008. *Lean Six Sigma Deployment* [Online]. Available at: http://lean.mit.edu/index.php?option=com_docman&task=doc_download&gid=1869 [accessed 22 November 2010].

Hines, P. 1995. Network sourcing: A discussion of causality within the buyer-supplier relationship. *International Journal of Purchasing and Materials Management* 31(2), pp 17-24.

Hines, P. 1996. Network sourcing: A discussion of causality within the buyer-supplier relationship. *European Journal of Purchasing & Supply Management* 2(1), pp 7-20.

Hines, P., Found, P., Griffiths, G. and Harrison, R. 2008. *Staying Lean, Thriving, not just surviving*. Cardiff: Lean Enterprise Research Centre, Cardiff University.

MOD. 2005. *Defence Industrial Strategy Defence White Paper* [Online]. Available at: http://www.mod.uk/DefenceInternet/AboutDefence/CorporatePublications/PolicyStrategyandPlanning/DefenceIndustrialStrategy/DefenceIndustrialStrategyDefenceWhitePapercm6697.htm [accessed 01 October 2010].

Seddon, J. 2003. *Freedom from Command and Control: a better way to make the work work*. Buckingham: Vanguard Education.

Seddon, J. 2008. *Systems Thinking in the Public Sector.* Axminster: Triarchy Press.

Slone, R., Dittmann, J., and Mentzer, J. 2010. *The new supply chain agenda: the five steps that drive real value* [Online]. Harvard Business Press. Available at: http://common.books24x7.com/book/id_36323/book.asp [accessed 28 October 2010].

Ward, Y. and Graves, A. 2006. *Through-life Management: A Catalyst for Process Excellence in Customer Support and Maintenance, Repair & Overhaul (MRO).* University of Bath.

Keywords:

SC21 initiative, quality, effectiveness, efficiency, Supply Chain, Supply Chain Integration, Supply Chain Management, Supply Chain Development, Supplier, Network Organisation, Supply Chain Strategy, Customer Supplier Relations, Partnerships, Supplier Coordination, Power, Trust, Equity, Develop Supply Chains, Channel Relationships and Value-Chain Management

PROCESS MAPPING AS A TOOL FOR IMPROVEMENT OF MANUFACTURING EFFICIENCY WITH APPLICATION TO PHARMASEUTICAL INDUSTRY

E. A. Yaseen, A. A. Abou Youssef

Faculty of Management Technology, German University in Cairo,
5th settlement, New Cairo, Egypt.

ABSTRACT
The purpose of this paper is to present a guide for the use of process mapping as a tool for implementing successful business process re-engineering (BPR). It provides a case study for the re-engineering undertaken by GlaxoSmithKline (GSK), one of the biggest multinational pharmaceutical companies worldwide. It reviews how process mapping was used in the application of BPR concepts within the GSK factory in Egypt.

The paper demonstrates process mapping applicability within different production lines. The actual results accomplished the critical success factors and tackled the major challenges from the point of view of GSK practitioners. The studied practices can be considered as good practices which can have wide applicability across various industries and business processes. These practices can be used as guidelines for process redesign for other factories, either within the pharmaceutical sector or in any other industrial sector aiming to reduce their total cycle time and achieve leanness in their activities.

Keywords:
Process mapping; simulation; Business process reengineering; workflow analysis.

INTRODUCTION:
Global competition, the innovative and rapid development of new services and products, and the reduction of cost of doing business are all among the major concerns of today's business organizations. To address such concerns, organizations must constantly reconsider and try to optimize the way they undertake business. During the last decade of the 20th century, organizations started the race towards implementing BPR. A numerous number of BPR methodologies have been proposed by academics as well as by practitioners. A close look at the concept of BPR emerged from observing the practices of highly successful organizations in the 1980s and early 1990s (Jarrar, 1999). The goal of BPR is to achieve dramatic improvements in business measures of performance by radically changing the process design.

Process mapping is one of the tools that have been used successfully in implementing BPR. Process mapping is an easily visualized process that facilitates analyzing and agreeing on the most efficient routes of reengineering or improving a process. "*It aids in determining redundant tasks, uncovering hidden interactions between processes and people, and focusing on the processes that serve customers, improve quality, add value, and generate income*" (Savory & Olson 2001). To understand BPR one has to learn from the world of business experience. It is vital to look at what others have done, their feedback, mistakes, results and overall approach to business processes re-engineering.

Overview:
BPR is considered as a fundamental rethinking, and major redesign of business processes. Its aim is to achieve improvements in different measures of performance such as cost, quality, service and speed. It was also shown that developing major re-design is a twofold challenge, socio-cultural and technical (Hammer & Champy, 1993). Manganelli & Klein (1994) investigated the different aspects of socio-cultural challenges that result from the organizational changes that usually accompany implementation of BPR. It was argued that those challenges usually result from changing work units from departments and functions to process teams, work scope from functional or departmental to cross functional, jobs from simple tasks to multidimensional work, people's role from controlled to empowered, job preparation focus from training only to training and education, reward system from activity based to result based, and the organizational structure from hierarchal to flat. they also argued that there are always ground rules for process re-

design and stated some specific redesign guidelines. These guidelines are consolidating activities, allowing employees who process the job to deliver it as well, redesigning for common data bases that are remotely accessed through networking.

Langdon (1999) defined process mapping as *"A step-by step description of the actions taken by workers, as they use a specific set of inputs to produce a defined set of outputs".* It is also known as system task analysis, process task analysis, process diagramming, and work mapping. A process map may focus on an entire organization, a business unit, a division, a function, a work group, or even an individual performer. Process maps are normally created by talking to the people who do the work—line managers, operators, and every other person involved in doing the task—and asking them to describe what they do. Based on the boundaries identified, manufacturing tours or service tours are conducted to get an understanding of the process, and then a flowchart is prepared (Martin, 2008). Rother & Shook (1998) summarized the application of process mapping into five phases to be implemented by a specialized team. These are selection of a product family, current state mapping, future state mapping, definition of a work plan, and achievement of the work plan.

Operations can generally be classified into three categories. The first is Non-Value Adding (NVA); pure waste and involves unnecessary actions which should be eliminated completely such as waiting time. The second is Necessary but Non-Value Adding (NNVA); may be wasteful but are necessary under the current operating procedures such as unpacking deliveries. The last is Value-Adding (VA); operations involving the conversion or processing of raw materials or semi-finished products through the use of manual labor such as body painting work (Monden, 1993).

Rother & Shook (1998) and Pavnaskar et al, 2003 studied the lean production movements which was originally developed and introduced the value stream mapping (VSM) technique as a functional method aimed at rearranging production systems from a lean point of view. Rother et al also summarized the implementation of the VSM process into five phases to put it into practice, using a special team formed for such a purpose, as follows: selection of a product family, current state mapping, future state mapping, definition of a work plan, and achievement of the work plan.

Serrano et al (2008) presented the results of a project whose main purpose was to evaluate the real applicability of VSM to redesign disconnected flow lines based on manufacturing environments with a diversity of logistical problems. The research was developed using a multiple case study methodology in six industrial companies. Experience has served to highlight the following results: the validity of VSM as a redesign tool is confirmed, resources required for the application process are established, and the differences between theoretical concepts proposed by VSM and their real world practical applications are indicated and analyzed. These findings will be assessed in GSK Egypt, the case study of this research. Also Hall (1993) concluded the following to redesign successfully: Set an aggressive re-engineering performance target. Commit 20 to 50% of chief executive's time to the project while assigning an additional senior executive to be responsible for implementation. And finally conduct a pilot of the new design. The pilot should test the design overall impact as well as the implementation process.

Research questions:
It is intended to answer the following research questions. If process mapping was applied at GSK, Egypt as was used by Serrano et all (2008), how can it be: 1) used as a tool for both identifying improvement needs and determining the underlying causes of the performance problems? 2) Used as a data collection method for identifying job duties and tasks? And 3) Implemented within pharmaceutical factories?

METHODOLOGY:
A case study was used to answer the research questions. In this case process mapping technique is applied on GlaxoSmithKline (GSK), a multinational pharmaceutical company. This is to assess the benefits gained from its implementation within GSK factory in Egypt.

As in any process design, structure may be specified by a set of logically related activities and resources that yield a certain output.

In this research it is assumed that the search space for new design structures is defined by two parameters: the number of full time employees (FTE) and the number of process activities. This means that factors such as organization and social issues that might affect the choice of new design are to be dealt with at later stages in the redesign process and will not be considered within the scope of this research. During the practical work, the team agreed on the following parameters as KPI's for improvement measurement: 1) Headcount reduction within certain activity. 2) Time reduction to finalize certain activity. 3) NVA elimination percentage from certain activity.

Scope and approach of process:
Five working days of interviews and observations **c**onducted by 4 experienced members in process mapping. Those are supported by 3 senior managers from different sites with broad experience across manufacturing and support function activities.

Practical work conducted (strategosinc.com):
Definition of the scope of the process; Selection of the working team; Conducting process mapping sessions; Brainstorming; Designing the future state process; Implementation of the new process.

The main steps followed during practical work:
There are **four main steps** that were used in the practical work in the process mapping exercise. **Step one** was the process mapping for the different production lines within the GSK factory. This was conducted by a team consisting of people from several departments such as engineering, maintenance, quality improvement, etc. It is important for process maps to be created by a team, rather than by an individual. As individuals can only influence the efficiency of the process components for which they are responsible. Process mapping is typically conducted by a facilitator. During the practical work at GSK a facilitator was nominated. The facilitator then arranged a small group of performers who are knowledgeable about the process. This group included the process owner, a top performers, and representatives from each work group that participated in the process. The facilitator asked the group to define the work groups involved, the process inputs and tasks, the sequence of tasks, the resulting outputs, and any other elements of importance. At GSK the process mapping approach was applied as follows:

- A map of the current process was developed showing activities and the corresponding employee type. Boxes and arrows were used to sketch the series of steps through which inputs must pass through transformation into a product.
- Value-adding (VA) and non-value-adding (NVA) activities were classified in order to eliminate the NVA activities through simplification, integration, and automation of activities.
- Load balancing for each employee is then measured in detail before and after the implementation.

The **second step** is data collection and resource utilization analysis. Actual operational data was collected for simulation and verification from the production planning department. Utilization costs of all production activities were collected from the finance department. All the collected data were stored in excel sheets. This is to compare the planning system data with the actual practical data that was observed and mapped by the team. The collected data also help in quantifying the benefits in terms of money.

Step three is to redesign the process. After analyzing the collected data, and measuring the VA/NVA percentages per employee per production line, the team went for brainstorming sessions and identified the bottlenecks, proposed and agreed on the relevant solutions. The team then finalized the drawing of the future state map for each line and shared it with the top management and the relevant stakeholders.

Finally the **fourth step** is the implementation and evaluation. This will be divided into **two phases**. **First,** is giving a chance to the operations department to implement the given recommendations, where the evaluation of the project will be in terms of head count reduction and time saving, and hence cost savings. **Second,** is the evaluation of the implementation by comparing workloads before and after the implementation, and quantifying the benefits in terms of headcount as FTE (Full Time Employees).

RESULTS AND DISCUSSION:

The process mapping team decided to select the area shaded in red color in figure 1 to conduct the detailed mapping. The selected area, the manufacturing of products, represents the highest time consuming area within the whole process. Some of the results concerning some of the manufacturing stages are in figures 2, 3, 4, and 5 in the appendix. It is worth noting that, in the before and after BPR state maps presented in the figures, the value and non value adding activities will not be equal at both sides. This is mainly due to the nature of the redesigned process and the way it is to be conducted with fewer numbers of operators.

Important hints for practical work:

- Process mapping requires a high level of facilitation skills to guide the mapping team.
- Process mapping team should consist of persons who like working with details.
- The quality of information provided depends mainly on the accuracy of collected data.
- Process mapping includes many hours of detailed observation, using stop watches and paper recording methods to capture detailed activities.
- Significant time is spent on agreement of opportunity and potential solutions with local management.

Identifying the Value Adding (VA) activity:

Three useful questions are recommended to assess if an activity is VA or NVA. The first is: does the event physically transform the product in some way? If so, it probably adds value. The second is: if the customer observed the event; would he refuse to pay its cost? If so, the event probably does not add value. The last is: if the event was eliminated, would the customer feel a difference? If not, the event is non value adding.

The practical results were very much encouraging and gave great outcomes concerning the reduction of NVA activities and headcount after the implementation of standard work, combining roles, and eliminating waste. As for the granulation line, fig.2, operators were reduced from 4 to 2 causing the NVA activities to drop from 76% to 33%. For the compression Machines, fig.3, operators were reduced from 4 to 2 giving a reduction in the NVA activities from 77% to 31%. Also for the automatic packaging line, fig.4, operators were reduced from 4 to 3 reducing the NVA activities from 54% to 52%. Overprinting area, fig.5, consisted of 3 ink jet over printing lines. They were working for one, eight hour shift. Two operators were dedicated for each of the 3 lines. By reviewing the process it was noticed that the second operator for each line was only doing a visual inspection check for the printed data, this was considered as pure NVA activity that can be totally eliminated, giving 50% reduction in headcount.

CONCLUSIONS:

This research investigates how process mapping is used by GSK factory in Egypt. The results illustrated several improvement opportunities which were identified and assessed as a result of the process mapping exercises conducted by the selected mapping team for different production lines within GSK factory. The research outcomes indicated that process mapping is a useful, efficient and applicable tool for tackling the redesign of production systems. This is apparent from the redesign results and in the satisfaction expressed by the implementation teams. As demonstrated in the results section (see also the appendix), a lot of improvement ideas were identified. These ideas include: cancellation of some non value adding activities, waste elimination regarding material and time, reduction of headcount, decrease of product cycle time. All of these improvements can be translated into financial savings for the company and improvement in competitiveness.

The main contribution of this research is that it provided a detailed guideline for how to conduct process mapping at any pharmaceutical factory in Egypt or elsewhere. It also succeeded in assessing process mapping as a tool for cost reduction and efficiency improvement within the industry. It also gave a positive answer to the research questions. The authors relied on the knowhow from (strategosinc.com) guidelines. Also the recommendations stated by other authors in the literature review were considered. The conclusions here confirm the guidelines provided by Serrano et al (2008), and its main achievement is the real improvement in the efficiency of production lines and cost savings resulted from headcount reduction.

The following can be concluded regarding the process mapping as a tool for business process re-engineering:

- Although customer focus has been seen as a key success factor, the primary uses of BPR were directly aimed at benefiting the organization, assuming that customers and other stakeholders may also gain from improved performance results.
- There was a shared determination by all successful organizations not to stop after succeeding and to move to the next step, mainly defined as continuous improvement.
- Many of the BPR cases reviewed achieved medium term cost and time saving rather than longer term strategic benefits. A greater focuses on working and learning could increase the strategic impact of many re-engineering applications.
- Human factors tend to be overlooked, and there is a great need for concentration of efforts to improve employees' working environment and learning processes.

During the practical work at GSK, Jarrar's (1999) conclusion was considered. Jarrar's note regarding "*no two companies were identical, nor they did tackle re-engineering in the same way*" was confirmed. This was evident by the fact that although GSK has 140 factories worldwide and although similar process mapping exercises have been performed within different GSK factories, yet each factory has always showed different degrees of resistance to the process mapping team recommendations. This was confirmed by some members in the process mapping team who participated in similar exercises within different GSK sites.

Also, it was concluded that there are some important points to be considered during the implementation of process mapping as follows:

- Process mapping is typically based on the input from a small group of employees. However, wider input can be achieved by circulating the draft map to a larger group for review and feedback.
- Process mapping requires a high level of facilitation skills to guide a group through the process mapping exercise.
- Persons who don't like working with details can find it very difficult to sit for the time usually required for creating a process map.
- As with most data collection methods. The quality of the data collected depends heavily on the accuracy of the information provided by the participating employees.

The case study at GSK established that the preparation of process maps offers:

- A structured approach that aids in understanding and assessing what is actually occurring in the factory of study.
- Process mapping is an analytical and communication tool that is designed to help in improving existing processes or implementing new improved ones. This can improve the efficiency of factories and processes.
- Process mapping can be a powerful tool, for both identifying performance improvement needs, and determining the underlying causes of performance problems. It was evident that once a process is mapped, it is easy to spot redundancies, omissions, insufficient work support, ineffective communication and work flow, and other obstacles that impact the work performance.
- Also the practical work at GSK proved that process mapping can also be an excellent data collection technique for identifying job contents. This is because during the identification of the work process, the specific procedures each person follows are described in detail.
- Process mapping provides a relatively low cost means of examining process improvements. This should usually happen before substantial capital is invested in a new product or process improvement effort. After the proposed design is

implemented, process mapping can provide a helpful method for evaluating the effectiveness of both the design and its execution. It provides data on how the design is actually being implemented and identifies both success and problem areas.

Recommendations for Future Research:
This research represents an analysis of three important process mapping aspects. These aspects are: technique efficiency, resources required for application and the gap between theory and practice. The research outcomes highlighted key points that can aid the practitioners to perform process mapping with greater efficiency. After conducting this research and from the above conclusions, some points appeared as areas for further research. These can be summarized as follows:

- The impact of human and culture factors on the success of redesign. Organizational and social issues that might affect the choice of new design should be addressed.
- The impact of BPR on culture change within the organization, sharing of knowledge between different factories and departments worldwide, and learning from each other's mistakes as well as best practices. This will create a learning culture within the organization and will aid in future sustainable improvement**.**
- The refinement of theory is needed. There is a large gap between theory as proposed in the process mapping literature and the level of usage in real-world applications. Research has demonstrated that the important issues that hinder the understanding of this phenomenon are the complexity of implementation and failing to appreciate its benefits. In this sense, numerous companies have adopted intermediate solutions that are less ambitious.

REFERENCES:

Hall, G., Rosenthal, J. (1993), "How to make re-engineering really work". Harvard business review, November-December, pp.119-131

Hammer, M., Champy, J. (1993), "Re-engineering the corporation: a manifesto for business revolution". London: Nicholas Brealey Publishing

Jarrar, Y. F. (1999), Business process re-engineering: learning from organizational experience. In: Total quality management & Business Excellence, vol.10, no. 2, pp. 173-186

Langdon, D. (1999). Process Mapping. In D. Langdon, K. Whiteside, & M. McKenna (Eds.) Intervention resource guide (pp. 311–317). San Francisco: Jossey-Bass/Pfeiffer. [Cited from: Martin, F (2008) "A PERFORMANCE TECHNOLOGIST'S APPROACH TO PROCESS PERFORMANCE IMPROVEMENT" Performance Improve-ment, vol. 47, no. 2. Published online in Wiley InterScience (www.interscience.wiley.com)]

Lean Manufacturing Strategy. Retrieved on 29-December 2010. From http://www.strategosinc.com

Manganelli, R., Klein, M. (1994), "The re-engineering handbook: a step by step guide to business transformation". NY: American management association.

Martin, F. (2008), "A PERFORMANCE TECHNOLOGIST'S APPROACH TO PROCESS PERFOR-MANCE IMPROVEMENT". Performance Improvement, vol. 47, no. 2. Published online by Wiley InterScience (www.interscience.wiley.com)]

Monden, Y. (1993), "Toyota Production System: An Integrated Approach to Just-in-Time" Industrial Engineering and Management Press, Norcross, 2nd edition

Pavnaskar, S.J., Gershenson, J.K. and Jambekar, A.B. (2003), "Classification scheme for lean manufacturing tools". International Journal of Production Research, Vol. 41 No. 13, pp. 3075-3090.

Rother, M. and Shook, J. (1998), "Learning to See: Value Stream Mapping to Add Value and Eliminate Muda". Lean Enterprise Institute, Cambridge, MA

Savory, P. and Olson, J. (2001), "Guidelines for Using Process Mapping to Aid Improve-ment Efforts", Hospital Material Management Quarterly, Volume 22, No. 3, pp. 10-16

Serrano, I., Ochoaz, C., Castro, R. (2008), "Evaluation of value stream mapping in manu-facturing system redesign". International Journal of Production Research, Vol. 46, No. 16, pp.4409–4430

APPENDIX: Practical Results

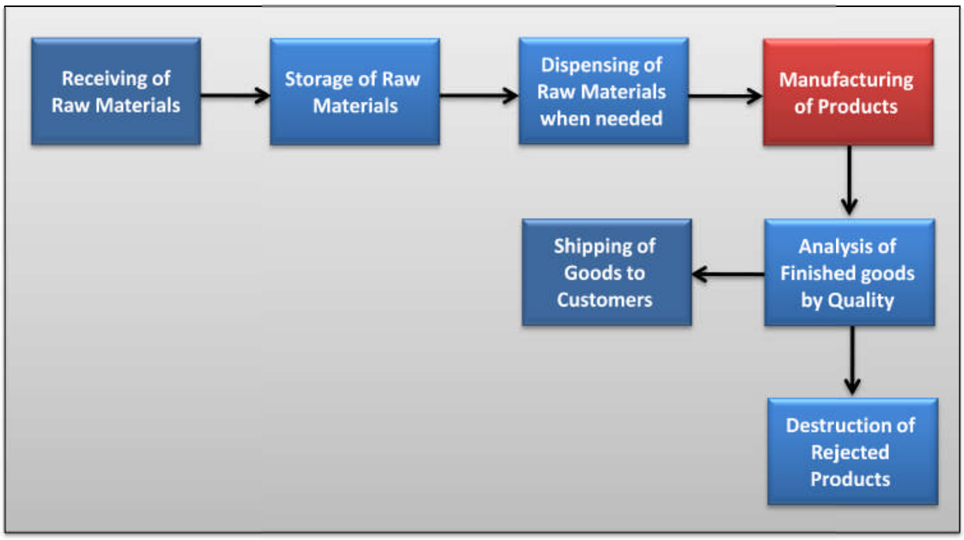


Figure 1: The manufacturing process flow

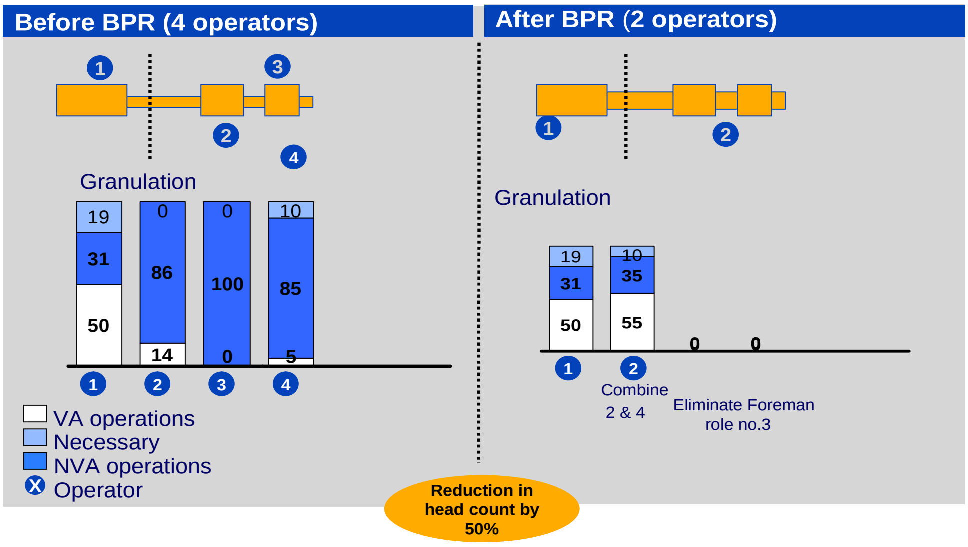


Figure 2: Granulation Line

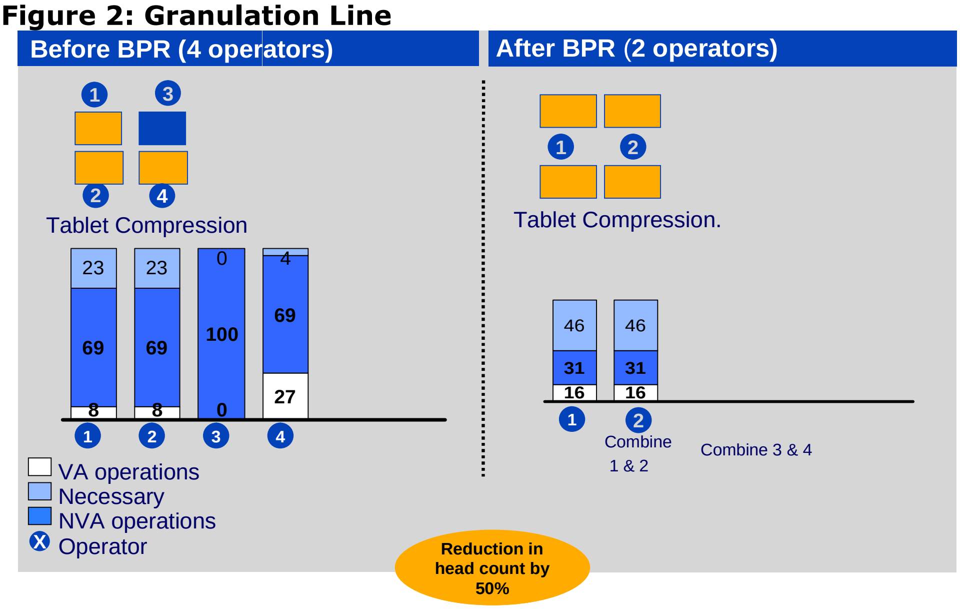


Figure 3: Compression machines

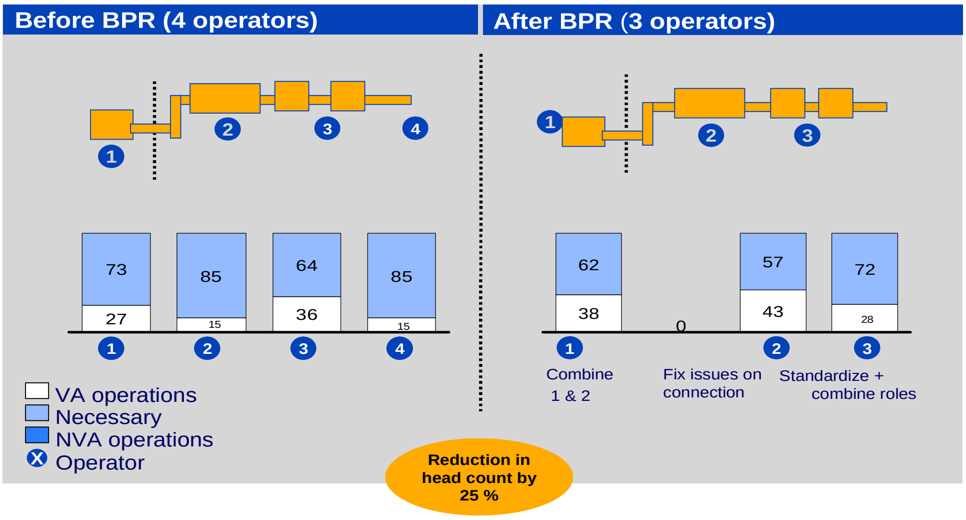


Figure 4: Automatic packaging line.

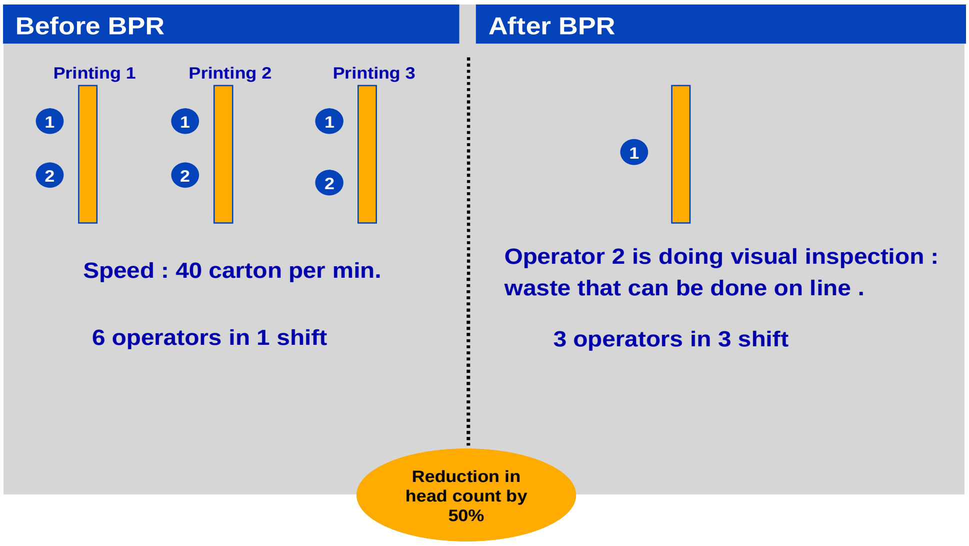


Figure 5: Overprinting lines.

AN EVALUATION OF CURRENT EUROPEAN PACKAGING REGULATIONS ON THE CORE LOGISTICS OPERATIONS OF A PAPER PACKAGING MANUFACTURER IN GREECE

Elias D. Georgakoudis, Nicoleta S. Tipi, Colin G. Bamford
Transport and Logistics Research Group, Huddersfield University
Email: u0572950@hud.ac.uk

ABSTRACT
This paper focuses on the packaging sector in the Greek logistics market. It seeks to evaluate in the broader sense the packaging operations and the potential problems such as barriers that a number of local laws, based on the European Packaging Directive 94/62/EC, might be generated in the individual markets. More specifically, the Greek market is a special field, where the effects caused by a number of measures formulated by the European Union, generate discrepancies compared to other member states, partly due to the geographical position of Greece and the distance from the central European market.

This paper also includes an investigation of a specific paper packaging supply chain, where paper packaging acts as a significant factor for the individual companies that participate within it.

INTRODUCTION

Packaging is defined as any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer (European Parliament, 1994). It can be categorized into three types: i) sales or primary packaging, ii) secondary packaging, iii) transport packaging.

Packaging has developed to a large extent in response to social and economic changes affecting consumers (Waste Online, 2005). The continuous economic growth in the western world that is translated in an on-going increase in consumer goods and the demand for more, new and innovative products has boosted packaging operations and transformed them into a vital factor for the whole supply chain.

Paper as we know it today was developed around 1867 and originated from wood pulp. Commercial paper bags were a real innovation for the second half of the 19th century. The first decade of the 20th century also signals the most dynamic starting point of the paper industry with the invention of machinery for the automatic production of in - line printed paper bags and boxes.

Kellogg Brothers were the first to use cereal cartons, protecting and advertising in this way their products and establishing paper as a well promised packaging material for the future (Berger, 2002).

PACKAGING ISSUE

Despite of the fact that the paper industry blossomed during the 20th century, the advent of plastics caused a strong shock to the paper sector during the late 1970's and the early 1980's. However, during the late 1980's new environmental concerns and the creativity of various designers stopped this trend and paper packaging again gained its strength, allowing new innovations and improvements in the sector.

In the late 1980's environmental issues emerged as an important factor and in many cases it became an increasingly important political issue (Livingstone and Sparks, 1994). Many countries that considered the significance of the problem tried to create a framework to determine how companies might operate in a more ecological way and protect the environment. The European Union has become involved in environmental legislation. However, despite the fact that until the end of the 1980's there were nearly 200 EC/EU directives concerning environmental areas, at least by 1990 more than 50% of these directives had not been implemented (Prendergast and Leyland, 1996).

In 1994 the European Union adopted the Packaging and Packaging Waste Directive (94/62/EU)[1]. This directive aimed to harmonize national packaging waste management measures, in order to reduce their impact on the environment and at the same time ensure that packaging laws did not create any obstacles to trade or restrictions to competition within the Community (The European Organization for Packaging and the Environment, 2000 and EUROPA, European Commission, Environment, 2005). This directive impacts not only on the internal market (EU) but the external market as well, since it puts specific features and details to the products manufactured and imported, from countries outside of the European Union.

However, although the specific Packaging and Packaging Waste Directive should ensure the avoidance of any obstacles to trade or restrictions to competition within the Union, there are complaints that the Directives create trade barriers. Furthermore, many believe that the directive and the new procedures that its implementation entails, are financially prohibitive for companies. It is obvious that the packaging issue needs careful attention since the balance between the implementation of a directive and the corresponding financial problems is fragile.

THE 94/62 EU PACKAGING AND PACKAGING WASTE DIRECTIVE

As cited above, the specific directive describes and integrates the European Union's strategy on packaging waste. It mainly aims to harmonize national management measures concerning packaging and packaging waste in order to reduce its impact on the environment and to efface any obstacles to trade or restrictions to competition across European Union member states, caused by the individual packaging laws (EUROPA, European Commission, Environment, 2005). It covers all packaging and packaging waste placed on the market in the EU, regardless of the materials used. The measure involves packaging manufacturers and importers and includes all packaging used or released at any level (industrial, commercial, service, household etc).

Member states are also required to:

- Create those facilities that ensure the return and collection of used packaging and packaging waste from the consumer, other final users, or from the waste stream, in order to channel it to the most appropriate waste management alternatives.
- Create those facilities that ensure the reuse or recovery of the packaging and packaging waste collected, in order to meet the objectives laid down in the specific directive.
- Encourage the use of materials obtained from recycled packaging waste from the manufacturing of packaging and other products (FOE, 1999).

The revised targets of the Directive are the following (European Commission, 2008):

- by no later than 30 June 2001, between 50 and 65% by weight of packaging waste to be recovered or incinerated at waste incineration plants with energy recovery;
- by no later than 31 December 2008, at least 60% by weight of packaging waste to be recovered or incinerated at waste incineration plants with energy recovery;
- by no later than 30 June 2001, between 25 and 45% by weight of the totality of packaging materials contained in packaging waste to be recycled (with a minimum of 15% by weight for each packaging material);
- by no later than 31 December 2008, between 55 and 80% by weight of packaging waste to be recycled;

[1] In 2004, the Directive was reviewed to provide criteria clarifying the definition of the term "packaging" and increase the targets for recovery and recycling of packaging waste.
In 2005, the Directive was revised again to allow new Member States transitional periods for attaining the recovery and recycling targets.
(European Commission, http://ec.europa.eu/environment/waste/packaging_index.htm)

- no later than 31 December 2008 the following targets for materials contained in packaging waste must be attained:
    - 60% for glass, paper and board;
    - 50% for metals;
    - 22.5% for plastics and;
    - 15% for wood.

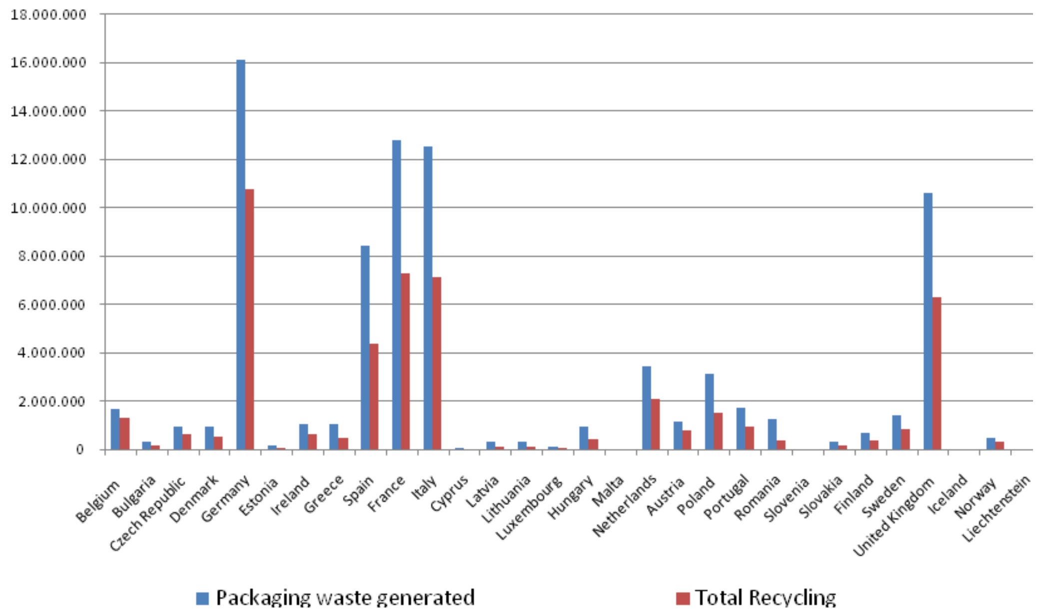


Figure 1 : Packaging Waste Generated and Recycling per Country (Weight)

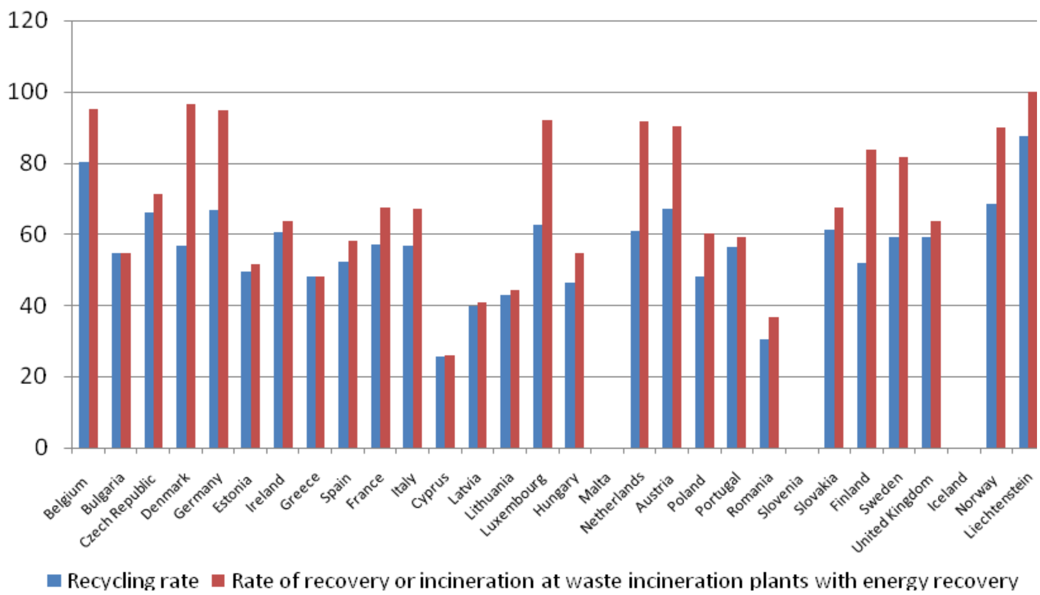


Figure 2: Recycling Rate and Rate of Energy Recovery per country (Proportion)

Data obtained from: The European Commission Environment, Packaging and Packaging Waste, "Results of packaging recycling and recovery in the Member States and in the EU",
Available at: http://ec.europa.eu/environment/waste/packaging/data.htm

The 2006 Report on the implementation of Directive 94/62/EC on packaging and packaging waste concluded that almost half of the Member States held derogations applying until 2015. Nevertheless, the objectives set for 2008 in Directive 2004/12/EC were to remain valid, even after 2008.

The most recent results of the Directive to Member States published by the European Commission, concern the year 2009 and are presented in Figure 1 and Figure 2.

Especially for the following countries:

- Greece,
- Ireland, and
- Portugal,

the Directive concludes that: "*because of the large number of small islands, the presence of rural and mountain areas and the low level of packaging consumption respectively, will not be bound by the targets until 2011*.

Directive 94/62/EC lays down essential requirements with which these countries should comply regarding the composition and the reusable and recoverable nature of packaging and packaging waste. The Commission is to promote the development of European standards relating to these essential requirements."

Finally, for the new Member States, the European Commission decided the following:

"Directive 2005/20/EC sets a later deadline for the 10 new Member States (the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovakia) to meet the targets of this packaging directive. These derogations are valid until 2015. Romania and Bulgaria have also been granted specific derogations, defined in their respective Treaties of Accession."

The main aims of the specific Packaging and Packaging Waste Directive and the individual laws enacted by other countries (e.g. Green Dot in Germany – trade mark protected in ~170 countries (Duales System Deutschland AG, 2005), are:

- to reduce packaging impact on the environment, and at the same time,
- efface any obstacles to trade or restrictions to competition within the Community,

There are complaints that these legislations create trade barriers.

For example, groups like Industry Council for Packaging and the Environment (INCPEN) and Alliance for Beverage Cartons and the Environment (ACE), at the end of the 1990's demanded the EC to take measures against Germany's refill quota, "*which put a 28% ceiling on drinks in single use packaging*" (Packaging Magazine, 1999). Because of the fact that the German system promotes the use of refillable containers, the system of deposits for non-reusable bottles is thought to be unfair for the foreign industries who in order to avoid these extra charges have not only to change their bottles transforming them into refillable but also to organize reverse, longer and expensive channels of transportation (comparing with the local manufacturers) in order to take back the empty bottles (UKEN Archive, 2001).

RESEARCH METHODOLOGY

Exploratory research has been used in the first part of the investigation to:

- Explain current practices in the packaging sector concerning packaging materials that are in use, reverse logistics issues such as methods of operation and costs, relevant legislation and in what proportion the packaging industry is affected by packaging laws.
- Investigate the recycling and recovery methods and operations that are in use in the European Union and to assess the extent to which they are appropriate from an environmental protection standpoint.

In order to answer the research question, a comparison was necessary between existing theoretical elements and the reality (including operations, methods and knowledge). For this reason, case study research of a general packaging supply chain was preferred, since this method enabled a more schematic and clear approach, allowing for a more in depth analysis and understanding of the research object (Yin, 1994, Miles and Huberman, 1994).

Questionnaires were sent to all different links of the supply chain, including Suppliers of raw materials, Packaging Manufacturers, Industrial Customers, Wholesalers and Retailers and Final Consumers. These five different questionnaires were designed and developed based on:

a. the specific needs and characteristics of the different links of the supply chain, and
b. the type of data required to be collected for the investigation,

including questions, especially designed for each link.

Of the 407 questionnaires totally sent, 368 questionnaires were finally returned (Response Rate: 90,42%), (2 from Suppliers, 4 from Packaging Manufacturers, 89 from Industrial Customers, 2 from Wholesalers-Retailers and 271 from Final Consumers). Common questions such as:

- *"Have you ever heard about the Packaging and Packaging Waste Directive (94/62/EU)?",*
- *"Do you think that the use of take-back programmes, for the collection of packaging from the Supply Chain is going to be affordable by the individual companies?"*

were used in all different questionnaires in order to have a better view of the situation. At the same time, the cost issue concerning the push of the industrial cost, by the individual participants to the final consumer, generated by the implementation of the Directive, was included in all questionnaires, except from the one developed for the investigation of the Final Consumers, who instead were asked for their buying habits and decisions with the following question:

- *"When you buy a product, you mostly base your choice on:*
    - *Price*
    - *Quality*
    - *Price and Quality*
    - *The Origin of the product*
    - *The environmental friendliness of the product*
    - *Other"*

From the data collected, the following can be concluded: 65% of the respondents were not aware of the Packaging and Packaging Waste Directive, 78% believe that the use of take-back programs is not affordable and is financially prohibitive for the individual companies, while 82% of respondents admitted that after the implementation of the Packaging and Packaging Waste Directive and the taxes that are going to be generated, they will try to push the cost to their customers through higher prices.

An interesting issue is that all of the Suppliers use their own vehicles for the collection of waste paper from the supply chain. At the same time all of them admitted that it is more environmental friendly in terms of energy and natural resources to produce new paper materials from virgin pulp, despite of the fact the recycling process consumes high volumes of natural resources such as water. Furthermore, 75% of the Paper Packaging Manufacturers support that nothing should be changed in the current procedures of collection of waste from the supply chain, since the market has already created those mechanisms ensuring that most of the paper waste generated is collected and sent for recycling.

Another interesting aspect is that 100% of the Paper Packaging manufacturers admitted that in case of a weight based taxation system[2] they would try to change the packaging they produce into lighter packaging, in order to decrease the amount of money they will be called to pay because of the taxation. However, in such cases the deterioration of the quality of the secondary packaging may cause serious problems due to damage to the product itself.

Concerning Industrial Customers, the most popular packaging material used is paper 94,4%, compared to 79% for plastic, 23% for glass and 24% for metal. At the same time 68% of them admitted that they have noticed damage to products during the handling process underlining in this case, the packaging quality issue.

What is relevant to Final Consumers is that the most common packaging material they recycle is paper with 54%. However only a small proportion of just 12% recycle all the packaging they use while 63% of them recycle only some of the packaging materials they use. A big proportion (75%) cited that they have bought/received a destroyed product at least once in the past, caused by destroyed or improper packaging. Most of the respondents (76%) answered that Price and Quality are the two most important factors affecting their buying decisions.

BARRIERS AND PROBLEMS

The research describes the present situation that exists in a supply chain, investigating the role of packaging, combining many different vital links, including producers of raw materials, packaging manufacturers, users and final consumers. The participants, contributed to an understanding of the problems that occur or might occur, in the specific supply chain after the implementation of the Packaging and Packaging Waste Directive (94/62/EU). The supply chain, consists of at least six different links, each one representing the different phases through which packaging reaches the final consumer.

More specifically, the supply chain includes the following different links:

a) The Supplier (the first link that undertakes to supply the whole supply chain with the necessary raw materials that will be used in packaging production),

b) The Packaging Manufacturer (the second link that is in direct connection with the supplier of packaging raw materials and its purpose is to transform raw materials into final packaging. In our case study, we describe a paper packaging manufacturer),

c) The Industrial Customer (the one who receives the packaging, in order to use it for the containing of the product),

d) The Wholesaler (although not ever present in a supply chain, the wholesaler acts as an intermediary for the product),

e) The retailer (the one who uses and receives the advantages of packaging and in many cases unpack the products from their secondary and transport packaging), and

f) The final consumer (the final link of the supply chain, that although in many cases does not see or use at all, the transport packaging and only receives the product contained in its primary or in some cases the secondary packaging, is the basic reason for the creation and use of packaging itself).

The diagram below clearly shows what is going to be the general structure of the case study. The flat lines indicate the original flow of packaging: raw materials, manufacturing process, final product, customer, 'retailer', final user while the dot lines indicate the reverse flow of packaging to the disposal or further to recycling centers.

[2] A system where the producers or users of the packaging, are charged with a fee, estimated based on the weight of the total packaging they use or produce.

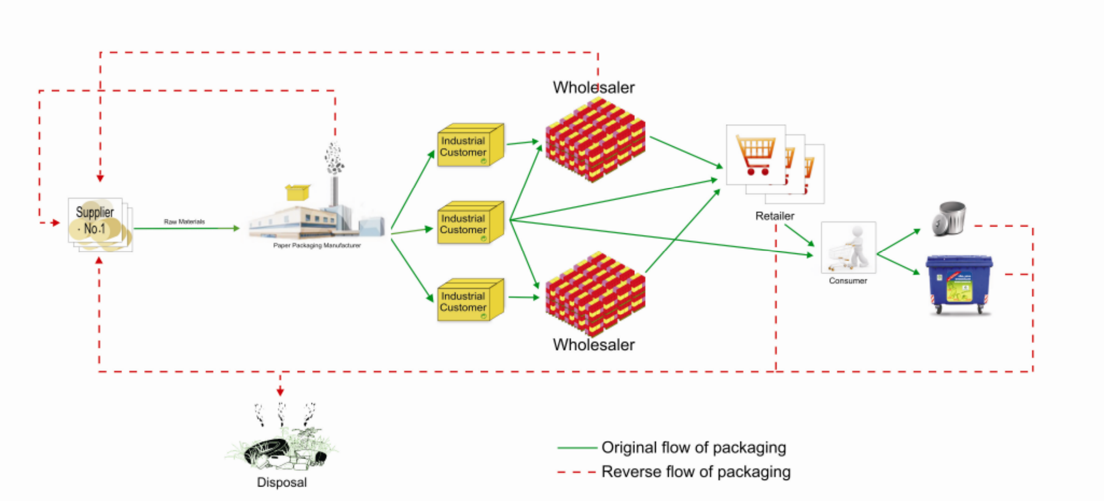


Figure 3 : The packaging Supply Chain

This research aims to investigate the role and importance of paper packaging in the supply chain and at the same time, to collect genuine data concerning the way in which the paper packaging materials aggravate the environment. Furthermore, it seeks to analyse the current recycling procedures concerning paper materials. Investigating the issue, it also aims to provide a critical assessment of current European packaging regulations, their success or possible problems generated by their implementation in different countries with lack of homogeneity and market conditions. It also covers the issue of trade barriers that might be generated from the implementation of relevant packaging directives.

In addition, through an extended supply chain case study based on the Greek market, the present research aims to provide an in-depth analysis of the role and performance of paper packaging. The quality of the packaging combined with the special characteristics of each individual supply chain, are of the most important factors for the transportation of products in the market with minimum damage or other logistical costs. The research also deals with the environmental issues that are relevant to packaging deterioration and various predictions are made concerning the relation of packaging quality and destruction.

Finally, another important aim of the present research is to evaluate the extent to which the packaging regulations, affect the prices of the packaged products to various EU-25 countries. (Especially here, the case of Greece has been used.) The push of cost is a matter of great importance affecting the competitiveness between domestic (European) and foreign (overseas) markets where regulations or other restrictions might be more elastic or less demanding, concerning environmental issues.

REFERENCES

(Anonymous (1994)), 'European Parliament and Council Directive 94/62/Ec of 20 December 1994 on Packaging and Packaging Waste' Vol. 94/62/EC [online] Available at: <http://www.herrco.gr/ConDows/Default/European_Parliament.pdf> [Accessed 19th November 2005]

Berger, K. (2002) 'A brief history of packaging', Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, reviewed by Welt, B. (2005)

Duales System Deutschland AG (2005) *Overcoming trade barriers – The Green Dot – an international financing mark for packaging recycling* [online] Available at: <http://www.gruener -punkt.de/Overcoming_trade_ barriers.282+B6kw9MQ___.O.html> [Accessed 26th September 2005]

EUROPA, European Commission, Environment (2005) *Guide to the Approximation of European Union Environmental Legislation, Part 2C. Overview of EU environmental legislation, Waste Management*
[online] Available at: <http://europa.eu.int/comm/environment/guide/part2c/htm> [Accessed 8th July 2005]

European Commission (2008) [online] Available at: http://ec.europa.eu/environment/waste/packaging_index.htm [Accessed 11th January 2011]

European Commission (2008) [online] Available at:<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1994L0062:20050405:EN:HTML > [Accessed 11th January 2011]

Livingstone, S. & Sparks L. (1994) 'The New German Packaging Laws: Effects on Firms Exporting to Germany', *International Journal of Physical Distribution & Logistics Management*, Vol.24, No.7: pp.15-25 MCB University Press, EBSCO Publishing

Miles, M.B. and Huberman, A.M., (1994), "Qualitative data analysis: An expanded sourcebook", Sage Publications Inc, Thousand Oaks, California

Packaging Magazine (1999) *EC acts on can ban*
[online] Available at: <http://www. dotpackaging.com/news/archive/environment/99_05_07. shtml> [Accessed 26th September 2005]

Prendergast, G. & Leyland, P. (1996) 'Packaging, marketing, logistics and the environment: are there trade – offs ?' *International Journal of Physical Distribution & Logistics Management*, Vol.26, No.6: pp. 60-72 MCB University Press, EBSCO Publishing

The European Organization for Packaging and the Environment, (2000) *Economic Instruments in Packaging and Packaging Waste Policy*
[online] Available at: <http://www.europen.be/issues/Economic_ Instruments.pdf > [Accessed 28th August 2005]

UKEN Archive (2001) *EU: German soft drinks packaging to be challenged in court*
[online] Available at: <http://www.ukenvironment. com/packagingwaste.html> [Accessed 26th September 2005]

Waste Online (2005) 'Packaging recycling information sheet'
[online] Available at: <http://www.wasteonline.org.uk/resources/Information Sheets/Packaging.htm> [Accessed 26th September 2005]

Yin, R.K., (1994), "Case study research: Design and Methods", Sage Publications Inc, Thousand Oaks, California

THE IMPACT OF CONTRACTUAL SAFEGUARDING ON THE EFFECTIVENESS OF OPERATIONAL COOPERATION GOVERNANCE IN LSP COOPERATIONS

Jan Simon Raue
The Kuehne-Foundation Chair of International Logistics Networks,
Technische Universität Berlin

Carl Marcus Wallenburg
The Kuehne-Foundation Chair of Logistics and Services Management,
WHU – Otto Beisheim School of Management

INTRODUCTION

Today, the majority of logistics service providers (LSPs) are engaged in horizontal cooperations with other possibly competing LSPs (Cruijssen et al, 2007; Schmoltzi and Wallenburg, 2011). Therefore, managing horizontal cooperations has become a major success factor for many LSPs. Among the tasks of managing these relationships, setting up effective cooperation governance is of major importance as it founds the basis for a successful partnership (Teng and Das, 2008). Here, LSPs can rely on a wide range of possible cooperation governance mechanisms. These governance mechanisms range from operational governance mechanisms applied on the operational day-to-day cooperation level to contractual governance or structural governance on the institutional level (Poppo and Zenger, 2002; Teng and Das, 2008; Kale et al., 2000). For effective cooperation governance, the selection of governance mechanisms on each of the different levels has, on the one hand, fit to the cooperation context. On the other hand, each mechanism has to be aligned with the other governance mechanisms in use. Therefore, a comprehensive understanding of the interplay of different cooperation governance mechanisms is necessary. First research works published about the management of horizontal LSP cooperation (e.g. Verstrepen et al., 2009) do not provide this comprehensive picture.

Therefore, this research aims for deeper insights into the outcome effects of two different operational governance mechanisms (formalization, relational capital) depending on the contractual safeguards applied. Thereby, it distinguishes between two different dimensions of contractual safeguarding, contractual coordination provisions and contractual enforcement provisions (Reuer and Ariño, 2007).

CONCEPTUAL FRAMEWORK

The outcome of LSP cooperations

Different approaches to assess cooperation outcome can be found in the literature (Kale et al., 2002; Nielsen and Nielsen, 2009; Perry et al., 2004; Zacharia et al., 2009). In order to evaluate the effectiveness of cooperation governance mechanisms of horizontal LSP cooperations we focus on three select outcome perspectives that are particularly affected by the choice of cooperation governance mechanisms (Lee et al. 2006; Yli-Renko et al., 2001). The first perspective is cooperation-based learning being the extent to which firms learn new knowledge from their cooperation partners. Second, cooperation-based innovation is the degree to which the cooperation fosters a company's innovativeness. The third perspective, cooperation-based performance, accesses the extent to which the cooperation fosters the performance of the company.

Interrelation of outcome dimensions

Nielsen and Nielsen (2009) suggest that cooperation-based learning drives the innovation of the cooperating firms. Learning provides a base of knowledge upon which innovations can be developed (Leonard-Barton, 1998) and increases the potential for new innovative solutions (Nielsen and Nielsen, 2009; Zahra et al., 2000). Furthermore, cooperation-based learning levers innovation through an increased willingness to develop new products (Yli-Renko et al., 2001). Thus, we argue that the extent to which cooperation partners learn from each other fosters the innovation projects in the partnering firms.

<u>*Hypothesis 1:*</u> *The degree to which a company learns from cooperation partners positively influences the degree to which the cooperation has fostered the innovation of the company.*

According to the literature, innovation is a lever for the success of organizations. Developing new products and services enables business units, single companies, and networks of autonomous organizations to gain competitive advantages necessary to compete in their markets (Daugherty et al., 2011; Dilk et al., 2008; Kandampully, 2002). In particular, the ability to adapt to new economical challenges and changes in customer demand more easily and accessing new markets (Grawe et al., 2009) are main success factors of innovators. Also for LSPs, innovation is considered a major lever for performance (Langley et al., 2005). Hence, we hypothize that the more cooperation-induced innovation horizontally cooperating LSPs realize, the more beneficial the cooperation will be for them.

Hypothesis 2: The degree to which a cooperation results in innovation for a company positively influences the degree to which the cooperation has fostered the performance of the company.

Governing LSP cooperations

Different studies indicate that the choice of governance mechanisms is crucial to the outcome of cooperations. These studies consider different types of cooperation governance, e.g. contractual governance (Poppo and Zenger, 2002), structural governance (Teng and Das, 2008) or operational governance (Kale et al., 2000). In this research we focus on two forms of cooperation governance: contractual and operational governance. Contracts set the legal parameters of the cooperation agreement whereas day-to-day governance of activities and processes is achieved through the use of operational governance mechanisms (Nielsen, 2010).

Operational governance

Operational governance includes both, formal and relational governance mechanisms. Formal governance involves rules, policies and procedures that are independent from personal relationships to govern the cooperation (Murray and Kotabe, 2005). Relational governance mechanisms are interpersonal and social in nature and mainly enhancing the building of trust and social identification (Dyer and Singh, 1998). To cover both perspectives this research focuses on one distinctive mechanism of each area. In particular, we focus on formalization as a formal governance mechanism and on relational capital as a relational governance mechanism. Formalization spells out detailed tasks, activities, schedules and operating procedures to govern the cooperation (Murray and Kotabe, 2005). Relational capital involves an atmosphere of forbearance, respect and balanced reciprocity. In addition, it creates a mutual confidence that no party will exploit others' vulnerabilities even if there is such opportunity (Kale et al., 2000). Both forms of operational governance are considered to facilitate cooperation coordination and reduce opportunistic behavior (Hoetker and Mellewigt, 2009), and therefore, to foster cooperation outcome. Hereby, improved coordination and reduced opportunism not only improve cooperation-induced performance (Lee and Cavusgil, 2006; Zollo et al., 2002; Luo, 2002) but also the degree to which a firm can learn from a cooperation and the degree to which a cooperation results in innovation for the respective company. Improved coordination includes higher intensity, frequency, and breadth of the exchange of business-related information (Larson, 1992) which are a associated with greater knowledge acquisition and innovation (Yli-Renko et al., 2001). Furthermore, the reduced risk of behaving opportunistically helps to align the incentives for sharing knowledge (Dyer and Singh, 1998) and to foster innovation (Ritala et al., 2009).

Hyopthesis 3: Relational capital has a positive influence on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance.

Hyopthesis 4: Formalization has a positive influence on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance.

Contractual governance and its interplay with operational governance

Cooperation contracts enable cooperation firms to set forth their mutual rights and obligations through the specification of inputs to the cooperation, processes by which exchanges will occur and any disputes will be resolved, and expected outputs from the joint undertaking (Reuer and Ariño, 2007).

In the literature, two main functions of cooperation contracts can be found. On the one hand, contracts enhance coordination (Li et al, 2010) and, on the other hand, contracts are a reducer of opportunism between cooperation partners (Heide, 1994). Accordingly, Reuer and Arino (2007) identify two different dimensions of contractual safeguarding: coordination provisions and enforcement provisions. Coordination provisions are informational provisions concerning the monitoring and adaptation of the cooperation mainly helping for effective coordination. Enforcement provisions deal with intellectual property as well as with breaches that involve lawsuits and third-party adjudication (Reuer and Ariño, 2007), mainly helping to directly reduce opportunistic behaviour between cooperation partners.

These two dimensions of contractual safeguarding are likely to differ in their interplay with operational governance mechanisms (Mellewigt et al., 2007) which are also in use to facilitate coordination and reduce opportunism. In the following, we look at this interplay in detail. First, we investigate how the use of coordination provisions influences the coordinating effect of the two operational governance mechanisms. Second, we focus on the influence of applying opportunism reducing enforcement provisions on the opportunism reducing effect of operational governance.

Governing for coordination

Whereas cooperation contracts form the basis for the coordination of inter-firm relationships in terms of articulating the conditions for governing transactions and identifying the mechanisms of knowledge transfer (Nielsen, 2010) on the institutional level. Operational formal governance mechanisms such as formalization facilitate cooperation coordination on the operational level.

Sobrero and Schrader (1998) conduct a quantitative meta-analysis which supports "the distinction of contractual and procedural coordination as two separate and complementary dimensions" of cooperation governance. Contractual coordination mechanisms are used to define the legal boundaries of the relationships whereas operational coordination is used to put into place the relationships within these institutional boundaries (Sobrero and Schrader, 1998). In the same vein, we argue that that the coordinating effect of contractual agreements is complemented by operational formalization. This mechanism defines how contractual coordination, i.e. agreements about the exchange of information between cooperation partners, is implemented on the operative level by defining standard operating procedures etc. Thus, we expect the positive effect of formalization on cooperation outcome to be stronger when more coordination provisions are applied.

<u>Hypothesis 5:</u> *The positive influence of formalization on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance increases when cooperation contracts contain more coordination provisions.*

In comparison to the coordinating effect of formalization we expect the relational governance to be at least partially substituted by contractual coordination provisions. Along with Mellewigt et al. (2007) who find evidence this for this view in HR cooperations we argue that coordination flows almost naturally from relational capital. Hence, the coordination effect of relational capital and contractual coordination provisions function independently from each other, and can therefore substitute each other. According to Ring and Van de Ven (1992), relational capital strengthens information sharing and coordination and, thus, allows for less contractual safeguarding. Consequently, we argue that the positive coordinating effect of relational capital on cooperation outcome decreases when cooperation contracts include more coordination provisions.

<u>Hypothesis 6:</u> *The influence of relational capital on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance decreases when cooperation contracts contain more coordination provisions.*

Governing against opportunism

Several prior studies have found evidence that the degree of contractual safeguarding in general depends on the risk of opportunistic behaviour (Heide, 1994; Joskow, 1987; Reuer and Ariño, 2007) as cooperation partners use contracts to decrease this risk. This effect is particularly achieved by the use of opportunism reducing enforcement provisions.

At the same time, the operational governance mechanisms formalization and relational capital are independently effective tools to decrease opportunistic behaviour (Carson et al., 2006; Parkhe, 1993; Kale et al., 2000). Operational formalization helps to reduce opportunism and to prevent opportunistic behavior from emerging as it establishes a framework to cooperate on a daily basis (Parkhe, 1993; Carson et al., 2006). The effectiveness of this framework is independent from the use of enforcement provisions. Relational capital involves an atmosphere of forbearance, respect and balanced reciprocity, and thus, creates a mutual confidence that no party will exploit others' vulnerabilities even if there is such opportunity (Kale et al., 2000) without relying on contractual enforcement provisions.

We expect the opportunistic behaviour decreasing component of operational governance to be interrelated with the use of contractual enforcement provisions in a way that they are able to – at least partially - substitute each other. Thus, we argue:

<u>Hypothesis 7:</u> The positive influence of formalization on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance decreases when cooperation contracts contain more enforcement provisions.

<u>Hypothesis 8:</u> The positive influence of relational capital on (a) cooperation-based learning, (b) cooperation-based innovation and (c) cooperation-based performance decreases when cooperation contracts contain more enforcement provisions.

Contractual governance and the interrelation of cooperation outcome

The degree to which cooperation partners can turn their knowledge acquired into the realization of new processes und service innovations within their firms depends on cooperation contracts. Knowledge acquired is more likely to lead to innovations in a cooperating firm when partnering firms - from which the knowledge derived - are not very concerned about intellectual property rights and their enforcement (enforcement provisions) as well as about the contractually institutionalized rights to monitor the processes of the cooperation partner (coordination provisions). Consequently, we argue:

<u>Hypothesis 9:</u> The positive influence of cooperation-based learning on cooperation-based innovation (a) increases when cooperation contracts contain more coordination provisions and (b) decreases when cooperation contracts contain more enforcement provisions.

We do not expect contractual safeguarding to influence the relationship between cooperation-based innovation and cooperation-based performance. Innovations already realized will impact the respective firm's benefits from the cooperation positively – independent from the contractual safeguards applied in both contractual dimensions coordination and enforcement.

<u>Hypothesis 10:</u> The influence of cooperation-based innovation on cooperation-based performance is positive independent from both, (a) coordination provisions and (b) enforcement provisions applied in cooperation contracts.

METHODOLOGY

Sampling and data collection

The data was collected with a web-based survey. The questionnaire was sent to executive managers of LSPs, who can be assumed to be well qualified as informants because horizontal LSP cooperations mostly lay in the responsibility of the top-management. The sample was drawn from a commercial company database containing firms from Germany with an annual turnover of more than € 1 million. LSPs with legal entities in Germany were identified as potential respondents. Overall, we could obtain valid email addresses for 3,661 LSPs, which received an invitation with a personalized link to the questionnaire. We received 389 responses leading to a response rate of 10.6%. 160 responses originate from LSPs that did not cooperate horizontally with other LSPs, whereas 229 responses originate from LSPs with relevant cooperation experience. Corresponding to our research aim, the responses from non-cooperating LSPs had to be excluded for the following analyses. Of the remaining 229 data sets, 20 were deleted because of incomplete data leaving 209 sets fur further analysis.

Two methods were applied to test for potential non-response bias (Wagner and Kemmerling, 2010). First, company demographics of responding firms were compared to those of the non-responding ones using available data from the company database. Second, survey data from early and late respondents was compared (Armstrong and Overton, 1977).

Measurement model

Construct measurement relied upon multi-item 7-point scales derived from logistics and strategic management literature. They were pretested to ensure face validity.

For assessing cooperation-based learning, we referred to the scale of Lane, Salk, and Lyles (2001) measuring to what extent firms have learned from their partners. Cooperation-based innovation was measured with the scale of Nielsen and Nielsen (2009) indicating the degree to which the cooperation resulted in innovations for the focal firm. Cooperation-based performance was assessed based on the performance scales of Perry et al. (2004) and Kale et al. (2002) reflecting to what extent the cooperation resulted in a better competitive position for the focal firm. Formalization was measured using the formalization scale of Murray and Kotabe (2005) from which one item was eliminated in the scale refinement process. Relational capital was assessed based on the scale of Kale et al. (2000).

To access the moderating effect of contractual safeguarding we used a measure of contractual provisions developed in a study by Parkhe (1993). Specifically, he developed a checklist of contractual safeguards obtained from a computer-assisted search of the legal literature. Respondents were asked if they used the contractual provisions of this checklist. Based on the results of an exploratory factor analysis conducted by Reuer and Ariño (2007) we distinguish between two dimensions of these provisions referring to the different functions of contractual safeguards: enforcement provisions and coordination provisions. By using the median split method (Simonin, 1999), the sample was divided into two subgroups for each dimension: first, a low coordination safeguarding group (N=80), and a high coordination safeguarding group (N=129), and second, a low enforcement safeguarding group (N=96), and a high enforcement safeguarding group (N=113).

Scale reliability and validity were assessed using SPSS and Amos. All Cronbach's alpha values were well above the suggested 0.7. In addition, the confirmatory factor analysis showed good model fit: $\chi^2/df=1.864$, CFI=0.964, TLI=0.954, and RMSEA=0.064. All factor loadings are significant at $p<0.001$, supporting convergent validity. Further, for all constructs the Fornell and Larcker (1981) criterion indicated discriminant validity.

Hypotheses test results

The fit of the structural base model indicates adequate model fit ($\chi 2/df= 1.844$, CFI= 0.964, TLI= 0,955, RMSEA= 0,064).

As displayed in Figure 1, cooperation-based innovation has a positive impact on cooperation-based performance (+0.46, p<0.001) supporting H1. Cooperation-based learning has a significant positive effect on cooperation-based innovation (+0.63, p<0.001) providing support for H2. Also H3a-c and H4a-c find support as formalization has a significant positive influence on cooperation-based learning (+0.31, p<0.001), cooperation-based innovation (+0.32, p<0.001) and cooperation-based performance (+0.16, p<0.1) and relational capital influences cooperation-based learning (+0.26, p<0.001), cooperation-based innovation (+0.15, p<0.1) and cooperation-based performance (+0.34, p<0.1) significantly positive.
The explanatory power of the model is substantial as the variance explained (R^2) for cooperation-based learning is 15.2%, for cooperation-based innovation 70.8%, and for cooperation-based performance 42.4%.

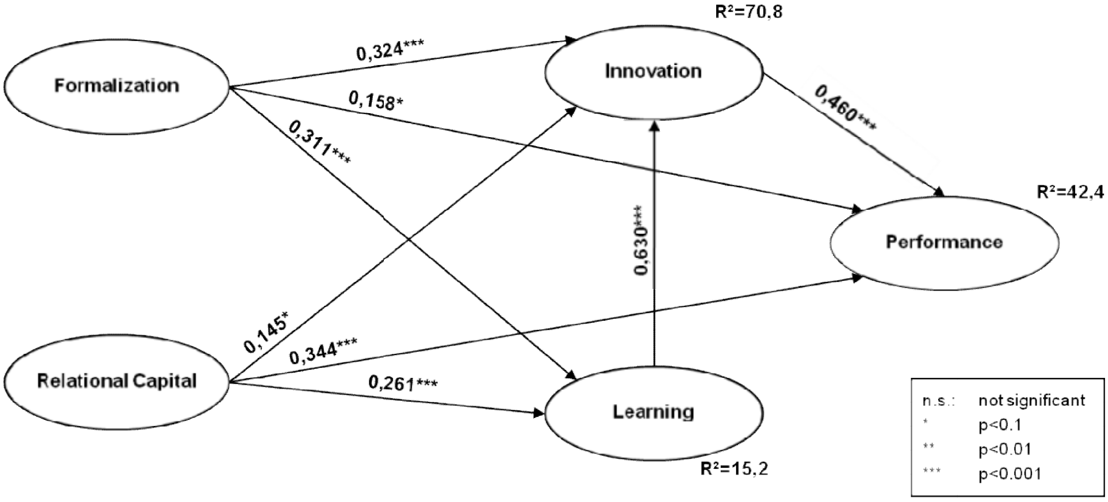


Figure 1: Base model

Moderating effects of the two dimensions of contractual safeguarding were assessed using multiple group analysis. All parameters of the structural model were estimated separately for the two subsamples under scrutiny and moderation was examined by conducting t-tests to verify the significance of differences between the structural paths (Wallenburg, 2009). As shown in Table 1, results for the moderation analysis of contractual safeguarding with coordination provisions indicate that, consistent with H5a and H5b, the positive effect from formalization on learning (p<0.001) and innovation (P=0.037) is significantly stronger when the use of coordination provisions is high. The positive effect from formalization on performance is slightly higher (although not significant) when the use of coordination provisions is low leading to the rejection of H5c. The positive effect of relational capital on cooperation-based learning is weaker when coordination safeguarding is high at a significance level of p=0.294 giving weak support for H6a. H6b and H6c find support as the effects of relational capital on cooperation-based innovation (p<0.001) and cooperation-based performance (p=0.018) are significantly weaker when the use of coordination provisions is high. The positive effect of learning on innovation is weaker when cooperation contracts contain more coordination provisions (p<0.001) supporting H9a whereas H10a has to be rejected as the effect of innovation on performance is stronger when coordination safeguarding is high.

Contractual Safeguarding Coordination	low (N=80)	high (N=129)	Significance of difference in path coefficient	Hypothesis
	Standardized path coefficient			
H5a: Formalization → Learning	0.23	0.30**	p<0.001	Support
H5b: Formalization →	0.30*	0.32***	P=0.037	Support

Innovation				
H5c: Formalization → Performance	0.20	0.18*	P=0.041	Rejection
H6a: Rel. Capital → Learning	0.28*	0.26**	P=0.294	Weak Support
H6b: Rel. Capital → Innovation	0.19*	0.09	p<0.001	Support
H6c: Rel. Capital → Performance	0.39**	0.36***	P=0.018	Support
H9a: Learning → Innovation	0.74***	0.58***	p<0.001	Support
H10a: Innovation → Performance	0.34*	0.53***	p<0.001	Rejection

Table 1: Results of moderation analyses for contractual coordination provisions

Table 2 displays the results of the analysis of the moderating effect of the use of enforcement provisions in the cooperation contract. H7a and H7c are supported by the results as the relationship between formalization and learning (p<0.001) and performance (p<0.001) is stronger when the use of enforcement provisions is low while H7b has to be rejected. Relational capital has a weaker effect on innovation (p<0.001) and performance (p<0.001) and a stronger one on learning when more enforcement provisions are part of the contract. This leads us to reject H8a and supports H8b and H8c. H9b is supported by our results because the effect of learning on innovation is stronger (p<0.001) when the contract contains only few enforcement provisions. Again the hypothesis for the relationship between innovation and performance (H10b) has to be rejected.

Contractual Safeguarding Enforcement	low (N=96)	high (N=113)	Significance of difference in path coefficient	Hypothesis
	Standardized path coefficient			
H7a: Formalization → Learning	0.36**	0.25*	p<0.001	Support
H7b: Formalization → Innovation	0.26*	0.33***	p<0.001	Rejection
H7c: Formalization → Performance	0.26*	-0.08	p<0.001	Support
H8a: Rel. Capital → Learning	0.23*	0.32**	p<0.001	Rejection
H8b: Rel. Capital → Innovation	0.23*	0.07	p<0.001	Support
H8c: Rel. Capital → Performance	0.45***	0.30***	p<0.001	Support
H9b: Learning → Innovation	0.71***	0.61***	p<0.001	Support
H10b: Innovation → Performance	0.29*	0.68***	p<0.001	Rejection

Table 2: Results of moderation analyses for contractual enforcement provisions

DISCUSSION AND IMPLICATIONS

Our results reveal a new perspective on the interplay of governance mechanisms and their effectiveness in horizontal cooperations. Recent research works in the field of cooperation governance examine the interplay of only two distinct governance forms, in particular whether relational governance and contractual governance are substitutes or complements (Poppo and Zenger, 2002; Mayer and Argyres, 2004; Reuer and Ariño, 2007). This research draws a more comprehensive picture by extending the view on cooperation governance in two ways. First, we not just look at one operational governance form as relational governance, but extend the view on a second form, operational formalization. Second, we contrast these operational governance forms with two distinct dimensions of contractual governance, coordination and enforcement, which differ substantially in their governance functions (Reuer and Ariño, 2007). Thereby, this research is responsive to Reuer and Ariño's (2007) call for further research.

Furthermore, when examining the interplay between the distinctive governance forms, our research goes beyond identifying the coexistence of governance mechanisms. It rather builds upon the outcome effects that originate from cooperation governance. Cooperation governance affects cooperation outcome through two levers: On the one hand, it facilitates the coordination of the cooperation, and on the other hand, it reduces the risk of opportunistic behaviour between the partners. We conclude that operational formalization and relational capital facilitate coordination while they also reduce the risk of opportunistic behaviour. The two dimensions of contractual safeguarding do not influence cooperation outcome through both levers with the same strength. Instead, coordination provisions of cooperation contracts mainly help to improve cooperation coordination whereas enforcement provisions primarily help to reduce opportunistic behaviour between cooperation partners. By comparing the outcome effects of operational governance mechanisms in groups where the use of contractual safeguards is high with groups in which its use is low, we show the interplay of operational and contractual governance forms.

First, we look at the interplay of contractual coordination provisions with operational governance. Here, consistent with our hypothesis the positive effect of operational formalization on cooperation-based learning and innovation increases when more contractual coordination safeguards are applied whereas the positive outcome effects of relational capital decrease. The coordinating effect of contractual agreements (i.e. agreements about the exchange of information between cooperation partners) on the institutional level is complemented by operational formalization (defining standard operating procedures etc.) on the operational level. In contrast, the coordinating effect of relational capital is substantially substituted by contractual coordination supporting our hypothesis that they function independently from each other.

Second, the interplay of enforcement provisions with operational governance was analyzed. Both forms of operational governance decrease their positive outcome effect in two of three outcome dimensions when the use of enforcement provisions is high. Formalization decreases its positive effect on learning and performance whereas relational capital decreases its effects on innovation and performance. This basically supports our hypotheses that the opportunism decreasing effect of operational governance can to a substantial extent be substituted by contractual enforcement provisions.

Our results provide guidance for managers implementing governance of horizontal cooperations. By applying coordination provisions in the cooperation contract the effectiveness of coordination through operational formalization can be substantially increased. Further, coordination provisions are able to compensate for a weaker coordinating effect of less developed relational capital. Our results also provide insights in how to govern against the risk of opportunistic behaviour. With regard to cooperation-based performance, contracts which anticipate the risk of opportunistic behaviour (with high use of contractual enforcement provisions) can compensate for both operational governance mechanisms, formalization and relational capital.

REFERENCES

Armstrong, J.S. und Overton, T.S. (1977), "Estimating Nonresponse Bias in Mail Surveys", Journal of Marketing Research (JMR), Vol. 14 No. 3, S. 396-402.

Cruijssen, Frans, Wout Dullaert, and Hein Fleuren (2007), "Horizontal Cooperation in Transport and Logistics: A Literature Review," Transportation Journal, Vol. 46, No. 3, pp. 22-39.

Daugherty, P., Chen, H. und Ferrin, B.G. (2011), "Organizational structure and logistics service innovation", International Journal of Logistics Management, Vol. 22 No. 1.

Dilk, C., Gleich, R., Wald, A. und Motwani, J. (2008), "State and Development of Innovation Networks: Evidence from the European Vehicle Sector", Management Decision, Vol. 46 No. 5, S. 691-701.

Dyer, J.H. und Singh, H. (1998), "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage", Academy of Management Review, Vol. 23 No. 4, S. 660-679.

Grawe, S.J., Chen, H. und Daugherty, P.J. (2009), "The Relationship Between Strategic Orientation, Service Innovation, and Performance", International Journal of Physical Distribution & Logistics Management, Vol. 39 No. 4, S. 282-300.

Heide, J.B. (1994), "Interorganizational Governance in Marketing Channels", Journal of Marketing, Vol. 58 No. 1, S. 71-85.

Hoetker, G. und Mellewigt, T. (2009), "Choice and Performance of Governance Mechanisms: Matching Alliance Governance to Asset Type", Strategic Management Journal, Vol. 30 No. 10, S. 1025-1044.

Joskow, P.L. (1987), "Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets", American Economic Review, Vol. 77 No. 1, S. 168.

Kale, P., Dyer, J.H. und Singh, H. (2002), "Alliance Capability, Stock Market Response, and Long Term Alliance Success: The Role of the Alliance Function", Strategic Management Journal, Vol. 23 No. 8, S. 747-767.

Kale, P., Singh, H. und Perlmutter, H. (2000), "Learning and Protection of Proprietary Assets in Strategic Alliances: Building Relational Capital", Strategic Management Journal, Vol. 21 No. 3, S. 217-237.

Kandampully, J. (2002), "Innovation as the Core Competency of a Service Organisation: The Role of Technology, Knowledge and Networks", European Journal of Innovation Management, Vol. 5, S. 18-26.

Lane, P.J., Salk, J.E. und Lyles, M.A. (2001), "Absorbtive Capacity, Learning, and Performance in International Joint Ventures", Strategic Management Journal, Vol. 22 No. 12, S. 1139-1161.

Langley, C.J.J., van Dort, E., Ang, A. and Sykes, S.R. (2005), Third-Party Logistics – Results and Findings of the 10th Annual Study, Georgia Institute of Technology, Atlanta, GA.

Larson, A. (1992), "Network Dyads in Entrepreneurial Settings: A Study of the Governance of Exchange Relationships", Administrative Science Quarterly, Vol. 37 No. 1, S. 76-104.

Lee, Y. und Cavusgil, S.T. (2006), "Enhancing Alliance Performance: The Effects of Contractual-Based versus Relational-based Governance", Journal of Business Research, Vol. 59 No. 8, S. 896-905.

Leonard-Barton, D. (1998), Wellsprings of knowledge: building and sustaining the sources of innovation, Harvard Business Press.

Li, Y., Xie, E., Teo, H. und Peng, M.W. (2010), "Formal Control and Social Control in Domestic and International Buyer-Supplier Relationships", Journal of Operations Management, Vol. 28 No. 4, S. 333-344.

Luo, Y. (2002), "Contract, Cooperation, and Performance in International Joint Ventures", Strategic Management Journal, Vol. 23 No. 10, S. 903-919.

Mellewigt, T., Madhok, A. und Weibel, A. (2007), "Trust and formal contracts in interorganizational relationships — substitutes and complements", Managerial & Decision Economics, Vol. 28 No. 8, S. 833-847.

Murray, J.Y. und Kotabe, M. (2005), "Performance Implications of Strategic Fit Between Alliance Attributes and Alliance Forms", Journal of Business Research, Vol. 58 No. 11, S. 1525-1533.

Nielsen, B.B. (2010), “Strategic fit, contractual, and procedural governance in alliances”, Journal of Business Research, Vol. 63 No. 7, S. 682-689.
Nielsen, B.B. und Nielsen, S. (2009), “Learning and Innovation in International Strategic Alliances: An Empirical Test of the Role of Trust and Tacitness”, Journal of Management Studies, Vol. 46 No. 6, S. 1031-1056.
Perry, M.L., Sengupta, S. und Krapfel, R. (2004), “Effectiveness of Horizontal Strategic Alliances in Technologically Uncertain Environments: Are Trust and Commitment Enough?”, Journal of Business Research, Vol. 57 No. 9, S. 951-956.
Poppo, L. und Zenger, T. (2002), “Do Formal Contracts and Relational Governance Function as Substitutes or Complements?”, Strategic Management Journal, Vol. 23 No. 8, S. 707-725.
Reuer, J.J. und Ariño, A. (2007), “Strategic Alliance Contracts: Dimensions and Determinants of Contractual Complexity”, Strategic Management Journal, Vol. 28 No. 3, S. 313-330.
Ring, P.S. und van de Ven, A.H. (1992), “Structuring Cooperative Relationships between Organizations”, Strategic Management Journal, Vol. 13 No. 7, S. 483-498.
Ritala, P., Hurmelinna-Laukkanen, P. und Blomqvist, K. (2009), “Tug of War in Innovation-Coopetitive Service Development”, International Journal of Services Technology & Management, Vol. 12 No. 3, S. 255-272.
Schmoltzi, C. and Wallenburg, C.M. “Horizontal cooperations between logistics service providers: motives, structure, performance”, forthcoming in: *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 5.
Simonin, B.L. (1999), “Ambiguity and the Process of Knowledge Transfer in Strategic Alliances”, *Strategic Management Journal*, Vol. 20 No. 7, S. 595-623.
Sobrero, M. und Schrader, S. (1998), “Structuring Inter-firm Relationships: A Metaanalytic Approach”, Organization Studies, Vol. 19 No. 4, S. 585 -615.
Teng, B. und Das, T. (2008), “Governance Structure Choice in Strategic Alliances: The Roles of Alliance Objectives, Alliance Management Experience, and International Partners”, Management Decision, Vol. 46 No. 5, S. 725-742.
Verstrepen, S., Cools, M., Cruijssen, F. und Dullaert, W. (2009), “A Dynamic Framework for Managing Horizontal Cooperation in Logistics”, *International Journal of Logistics Systems and Management*, Vol. 5 No. 3-4, S. 228-248.
Wagner, S.M. und Kemmerling, R. (2010), “Handling Nonresponse in Logistics Research”, Journal of Business Logistics, Vol. 31 No. 2, S. 357-381.
Wallenburg, C.M. (2009), “Innovation in Logistics Outsourcing Relationships: Proactive Improvement of Logistics Service Providers as a Driver of Customer Loyalty”, Journal of Supply Chain Management, Vol. 45 No. 2, S. 75-93.
Yli-Renko, H., Autio, E. und Sapienza, H.J. (2001), “Social Capital, Knowledge Acquisition, and Knowledge Exploitation in Young Technology-based Firms”, Strategic Management Journal, Vol. 22 No. 6/7, S. 587. doi:10.1002/smj.183
Zacharia, Z.G., Nix, N.W. und Lusch, R.F. (2009), “An Analysis of Supply Chain Collaborations and Their Effect on Performance Outcomes”, Journal of Business Logistics, Vol. 30 No. 2, S. 101-124.
Zahra, S.A., Ireland, R.D. und Hitt, M.A. (2000), “International Expansion by New Venture Firms: International Diversity, Mode of Market Entry, Technological Learning, and Performance”, Academy of Management Journal, Vol. 43 No. 5, S. 925-950.
Zollo, M., Reuer, J.J. und Singh, H. (2002), “Interorganizational Routines and Performance in Strategic Alliances”, Organization Science, Vol. 13 No. 6, S. 701-713.

GLOBAL SUPPLY CHAIN AND THE EUROPEAN TEXTILE INDUSTRY

B. Moncef[1], M. Monnet[2], M. Benhouda[3]
[1] École Supérieure de Commerce Extérieur Paris La défense (btissam.moncef@esce.fr)
[2]Cret Log (marlene.monnet@gmail.com)
[3]Université de Nantes (benoudamohamed@hotmail.com)

Abstract:
The logistics organization of the textile sector changed extensively in Europe in recent years. Increased national and international competition, changing supply and consumption patterns, the development of textile chains in Europe and emerging logistics issues have led to significant changes. This includes outsourcing development, more sourcing in low-cost countries, shorter product life cycles in the seasonal collections and the development of new distribution channels.
Through analysis of the textile sector and analysis of the literature on international supply chains, the aim of this paper is to understand these sourcing in low-cost countries phenomena, to see its impact on the overall performance of the supply chain, and then, to propose a synthesis of innovative and inter-sectoral solutions.

Keywords: supply chain management performance, sourcing in low-cost countries, fourth party logistics and textile sector.

1 INTRODUCTION
The logistics organization of the textile sector has changed extensively in Europe in recent years. Increased national and international competition, changing supply and consumption patterns, the development of textile chains in Europe and emerging logistics issues (management of sales, restocking, unsold articles...) have led to significant changes including outsourcing development, more sourcing in low-cost countries, shorter product life cycles in the seasonal collections and the development of new distribution channels.

A thorough analysis of the textile sector reveals a restructuring of its double supply chain for upstream constraints related to low-cost sourcing (imports characterized by large quantities of supplies, long time delays, and long term planning and delivery of products) as well as for downstream constraints related to e-commerce (private sales where responsiveness and inventory optimization are important parameters).

Based on professional experience and a review of international supply chain literature, this article highlights some of the levers which generate better performance and reduce the percentage of logistics costs and quality problems. Thus, we first analyze the new trends in textile sector; secondly, we highlight the problems related to sourcing in low-cost countries; and finally, we discuss a range of possibilities in order to achieve improved performance in a context of globalization.

2 CURRENT SITUATION AND KEY TRENDS IN THE TEXTILE SECTOR
The textile and clothing sector has experienced a wave of offshoring which represents a very important movement to low-cost countries in order to reduce production costs. The major Asian countries with vertically integrated industries have become major global suppliers. China in particular produces all types of textiles and garments in all ranges of quality and price. In this regard a substantial number of mergers, partnerships, joint ventures or alliances have emerged. Sourcing in distant countries has been developed with the main objective of reducing production costs.

Before addressing this phenomenon in depth, the analysis of characteristics of textile products is essential in order to understand the textile supply chain. In fact, the nature of textile leads to multiple forms of sourcing and constraints to be taken into account. Globally, three categories of products can be presented:

- **Basic products**: characterized by the massive quantities of procurement and the large-scale development of imports to ensure the best price and greatly reduced production costs. Companies sourcing in large quantities in Asia often find reductions in their purchases on the order of 30 %. The real differentiation is in the dealer's ability to control logistics costs and to develop a supply chain robust enough to avoid losing supply cost gains made on purchases and to minimize the risks of partial delivery and late arrival of containers.

- **Midrange products**: seek to reconcile low-cost sourcing and responsiveness to the delays in rapid restocking these products, which are more likely impulse items than essential purchases. The principle of dual sourcing is adopted to ensure responsiveness: the first order is made on a massive level; however, replenishments are effected with suppliers in closer proximity in order to ensure responsiveness. In this way through partnership agreements, which include the reservation of capacity and inventory materials, some channels are now able to replenish in three weeks compared to eight weeks for other more distant mass suppliers.

- **Fashion products**: accomplish sourcing through a short circuit in order to anticipate and follow selling trends. In this case a dedicated budget is established before the season so as to anticipate any errors or inadequate anticipation of trends.

Otherwise, major retailers in the European Union (EU) generally work with two types of suppliers of textile and clothing:

- The "mega-firms", which have headquarters in Asia and production networks scattered around the world and which achieve economies of scale to produce mostly basic items at low-cost and high volume (t-shirts, pullovers, trousers, underwear and woven shirts).

- Businesses in closer proximity which demonstrate high skill levels and flexibility, provide preferential access to markets, and are able to quickly provide small quantities of products with higher added value.

The different characteristics of these products allow us to construct a typology based on life cycles and sourcing zones as showed in Table 1.

Product categories	Life cycle	Sourcing zone
Basic products	6 months to 1 year	Asia
Midrange products	6 weeks to 3 months	Maghreb
Fashion products	4 to 6 weeks	Euro-Mediterranean

Table1: Categories of Textile Products

Regarding distribution channels, the textile and clothing industry is highly competitive, divided into small segments (market leaders hold only 3 to 4% of the market share), and influenced by a strong downward pressure on prices. Hypermarkets which continue to dominate in volume sales tend to deal with specialists. The major international channels (H & M, Zara...) have introduced innovations including the presentation of mini-collections and the release of new products in a short period of time.

In order to accomplish these adjustments, three possibilities of improvement for the supply chain can be considered:

1. Accelerating the time-to-market component
2. Enhancing the risk management policies in assembling each collection
3. Optimizing the logistical costs throughout the chain (including arbitration between risk of rupture and risk of overstockage)

These improvement targets have become increasingly difficult to achieve given the new context of sourcing. Indeed, motivated by lower production and purchasing costs, companies have neglected to take into account the hidden costs behind this method and are now forced to incorporate new parameters. Fisher (1997) explains that offshoring will increase the supply chain costs of transportation, handling, warehousing and inventory and market mediation costs.

3 SOURCING IN ASIA : A NEW CONTEXT

3.1 The increase in production costs

The explosion of production costs in China is disrupting existing business models. This has led some groups already to plan to produce up to 50% of their products in the other Asian countries, such as Thailand, Bangladesh, Vietnam and Cambodia. Rising costs are affecting the entire chain of production due to a number of local factors as well as to international factors such as the explosion of commodity prices and energy.

Another reason for the increased costs of production is the strong economic growth in China which has increased wages and living standards for workers in manufacturing as well as services sectors.

The abolition in 2007 of a tax rebate on exports for some 2500 low-value-added products manufactured in China has also resulted in increased supply costs. The present economic objectives of China are to optimize energy consumption and to develop the manufacture of products with high added value. China wants to evolve into a more sophisticated profile of specialist in complex industries.

3.2 Quality problems

After sitting for three weeks in containers at sea, products can often arrive crumpled, damaged, without labels, and with manufacturing defects. Other products, such as clothes, can require repackaging before reaching stores. A final step of reconditioning is thus necessary before sending items to stores. As a result, new subcontractors have begun to offer their services: reception and dispatch of fabrics and haberdashery, provision of hangers and placement of clothing on hangers or folding of clothes, steaming and ironing of items, quality control, dislodging pieces, preparation of customer orders, and so on.

Moreover, an important factor is that items with manufacturing defects can result in loss of sales, disappointed customers, unsold products and, of course, losses of revenue. Meanwhile, some products, which have been manufactured and shipped, will never be sold because the need for them has been poorly anticipated. These unsold items must be dumped at a loss or even destroyed. Thus, an effective control system must be implemented to monitor manufacturing and ensure that it follows prescribed guidance and respect for quality standards.

3.3 Responsiveness

Textile enterprises must manage a paradox: combining the geographic remoteness of their purchases at low prices to their need for high reactivity through a series of increasingly short product life cycles or high turnover situations. Delivery times from Asia are too long and maritime schedules are incompressible for the most part. The use of airfreight is a very expensive, and most often unacceptable, alternative. All of these forces demand that importers anticipate numerous market and logistical factors well in advance of their orders in the context of a market permeated with a high degree of uncertainty. In this context, timely reactivity is becoming more and more difficult and expensive.

Figure 1 shows the physical supply chain of sourcing in low-cost countries. In the upstream, sourcing in distant countries involves long delays, mass quantities, standard products and forecasts which need to be completed several months in advance. This is in direct contrast with the constraints of downstream factors such as short delays (two or three days), e-commerce, unpredictable customer requests, and supplies in small quantities.

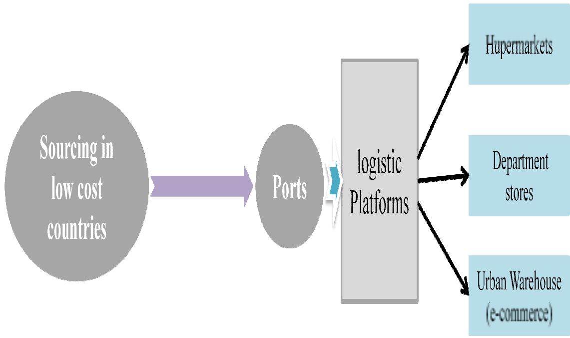


Figure 1: the physical supply chain of sourcing in low-cost countries

In this context of unpredictable demand and long lead-times, some practices like postponement are difficult to follow. In the upstream of this SC practice, the processes are designed to maximise efficiencies through standardisation and economies of scale; on the other hand, in the downstream, the processes are designed to be highly responsive to actual demand (Naylor et al., 1999; Lowson, 2002). But, in the context of sourcing in low-cost countries, textile companies can not carry inventory in a generic form and assemble/configure and distribute as required when customer demand is encountered.

This current trend is also contrary to the pull and lean philosophies and to optimization practices like JIT, Kanban, TQM, SRM and CRM which have successfully shortened production and supply cycles and decreased inventories enabling companies to answer customer needs quickly and accurately.

Through an empirical study (including a quantitative survey on a sample of 150 firms and a qualitative part with 20 in-depth interviews) on the impact of sourcing manufactured products from low-cost countries, Moatti (2008) confirmed that sourcing from low-cost countries has a strong negative impact of such movements on the supply chain performance metrics.

According to this study, Moatti (2008) classified the consequences for the Supply Chain of sourcing in low-cost countries into two main groups, as shown in the table 2.

Inevitable consequences that have to be anticipated	Effects that call for special management in order to reduce their harmful consequences:
-Costs incurred for transport and formalities customs, -The planning process becomes a more complex task, -Products have to be checked on receipt and packaged, -Flow organization and supervision become more complex tasks.	-A lesser ability to react to significant fluctuations in demand, -Quality problems, -Greater unreliability of deliveries, -Counterfeiting.

Table 2: Consequences of sourcing in low-cost countries
Source: Moatti 2008

Generally, characteristics of low-cost countries supply chains such as long geographic distances, increased delivery times, and decreased delivery precision may increase costs in terms of expedited freight, unfulfilled demands, extra inventory, and managerial time spent on “fire-fighting” extra freight and administrative costs, reduced flexibility and planning ability, low product quality and reduced customer service (Levy, 1995; Lowson, 2003; Brannemo, 2006; Moatti, 2008; Fredriksson and Jonsson, 2009). In order to achieve the necessary flexibility, companies need to increase inventories or have a second source locally. However, value inventories increases as they approach the customer and the decisions taken earlier can increase the cost of inventory in downstream. Consequently, characteristics of low-cost-country supply chains may affect the performance of logistics and thereby decrease the sought-after positive effects of outsourcing, such as cost savings (Fredriksson and Jonsson, 2009).

These performance criteria can be summarized by the five basic performance objectives presented by Slack et al (2007) and applied to all types of operation: product quality, speed, dependability, flexibility, and cost. These variables of operational performance can help to measure the performance of supply chain sourcing.

Faced with rising production costs and problems of reactivity, the textile industry is in search of solution. We will try to summarize the most important new trends which have emerged.

3.4 Life cost cycle approach applied to sourcing in low-cost countries

In the Asian context, the labor and production cost are low until the retail level. On the other hand, delays and delivery costs to the retailer are substantial and increase total logistics costs. The difficulty is to prevent these logistics costs from becoming a recurring cost thus reducing or canceling the financial gains obtained through the lowest procurement and production costs. Therefore, sourcing in operations of low-cost countries should be designed in the form of a project with a logical life cycle cost (LCC). Indeed, in logistics management many problems in the operation occur because both direct and indirect consequences of specific decisions are not taken into account in the organization of the whole system (Christopher, 2005).

The environmental and economic performance of a product includes all phases of the life cycle of the product from extraction of raw materials until the end of the product life. Thus, the LCC approach has been formulated to enable a comprehensive analysis of costs in order to improve economic performance (Park and Seo 2004). For these authors, the LCC analysis is a tool that produces important parameters through the cost-effectiveness of a range of alternatives.

The question for managers is how to incorporate the hidden costs of sourcing in low-cost countries into the total cost of the product life cycle in order to balance sourcing decisions. By integrating these parameters, selection of fashion and design areas may allow for appropriate conduct resulting in large savings of time and cost. The various business objectives must be weighed in determining the models of product design. The LCC approach is very relevant to current managers; it can analyze and estimate the overall economic viability of a sourcing project while integrating all related costs of sourcing and its repercussions on the supply chain as a whole.

4 THE CONSEQUENCES OF SOURCING IN LCC ON THE TEXTILE SUPPLY CHAIN

To create stable and cost efficient supply chains, it is important to match the right product with the right partners at the right location and sourcing (Fredriksson and Patrik 2009). Low-cost countries imply certain characteristics of partners and location; and sourcing from these countries requires that companies are aware of these characteristics (Fredriksson and Patrik 2009). In this last part, we will conduct an analysis of sourcing strategies according to geographical characteristic's location.

We have identified three different Supply Chains for each clothing product type through the analysis of sourcing strategies according to geographical location (figure 2) :

- The Euro-Asian supply chain for basic products for which mass production, punctuality and regularity of supply are important.
- Euro-Mediterranean supply chain for midrange products to benefit from the proximity advantage.
- Supply chain sources of closer proximity for fashion products for which responsiveness to fashion trends is important.

Thus, to reduce complexity and to adapt to different constraints, two major organizational trends are emerging for these three supply chains types: the return to sources in the Euro-Mediterranean zone and the monitoring of the supply chain by a fourth party logistics provider.

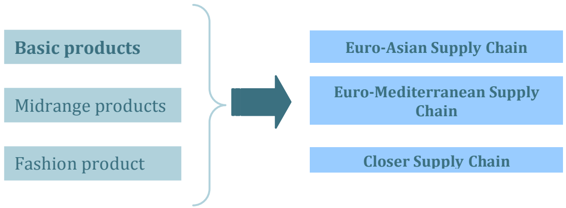


Figure 2: Segmentation of the SC textile by product typology

4.1 Back to the Mediterranean zone

Sourcing decisions affect the supply network configuration; and the coordination of supply network is contingent upon the configuration (Rudberg and Olhager, 2003). Both the configuration and the coordination affect how flow and the storage of goods and information exchange should be managed in a supply network. That's the reason why some major textile companies reactivate their short logistic circuits in the Mediterranean in order to cope with the accelerated cadence of fashion with which an Asian supply is far less compatible. So depending on the nature of the products, these firms are moving towards a mix of short circuits for the fashion and delicate products and long for mass market products. Thus, the tactics adopted is influenced by whether the product is "standard" or "special" (Pagh and Cooper, 1998).
In
Indeed, even if the costs of sourcing in the Mediterranean countries are higher than Chinese costs due to workforce efficiencies (six times higher), these countries remain a near source and provide an interesting quality-price ratio.

In fact, economies of scale achieved through mass production can not cover products that require differentiation at the end of the chain. This allows the company to delay decisions until the emergence of other additional information effecting a reduction of uncertainty and risk (Garcia-Dastugue et Lambert 2008). It should be noted however that production in neighboring countries will allow the recovery of supply differentiation. Hence the need to relocate production to reduce delays, fragmentation and time to market.

New global logistics hubs for the relocation of production activity have been created or developed to motivate the global companies to relocate their production activity to the Euro- Mediterranean zone. For example, Morocco has conducted an important infrastructure "*Tanger Med*" with approximately eight million TEUs of capacity. This is an excellent illustration of what may be the new global logistics platform.

However, despite the problems of sourcing in low-cost countries and more precisely those in Asia, characteristics of these countries are still attractive; the Asian market still has a competitive economy, especially as it remains a highly attractive market in terms of its size and its potential for economic growth. Relocation can only affect a part of sourcing, and the remainder can continue to be sourced in Asia. That is why other solutions must be considered.

4.2 The monitoring solution of the textile supply chain: the 4PL

Through the analysis the supply chain models of several textile companies, a trend towards the outsourcing of various operations indicates a change from focusing on sourcing to focusing on the heart of the business: fashion. Thus, some companies such as Inditex manage their supply chains by outsourcing only transportation, while other textile companies like Kiabi have chosen a hybrid model that allows them to manage some operations and outsource others. Finally, a group of companies decided to outsource all operations of sourcing to focus on product design (Faconnable, Zadig and Voltaire, Carrefour, Casino, Cora ...)

Given this model, we can see that the risks to be managed are increasingly numerous. Several actors are involved in each value chain and companies must establish an efficient communication system to manage the end-to-end chain in order to adjust to design delays, to monitor manufacture and supply quality, and to control abuses of purchasing costs and transportation.

Commonly, the supply chain design problem includes the decisions about the number and location of production facilities, the capacity at each facility, the assignment of each market region to one or more locations, and the supplier selection of sub-assemblies, components and materials (Chopra and Meindl, 2004). Thus, the supply chain design is made more difficult and complex because of the internationalization of sourcing.

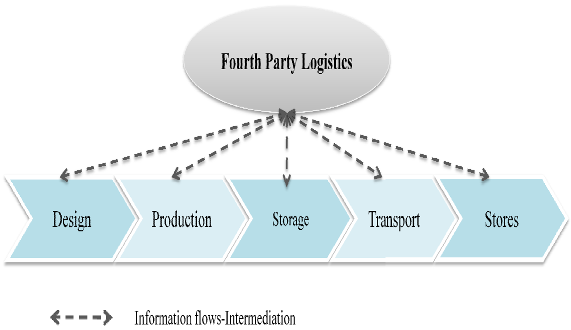


Figure 3: The 4PL as organizer of sourcing in low-cost countries

This internationalization and fragmentation of flows made more difficult by geographical and cultural distance requires coordination by a logistic service provider (LSP) able to inspect and to manage the supply chain when production and purchasing are made in distant areas. Some authors (François et al., 2009) were interested in the LSP and especially in the "fourth-party logistics" 4PL. The authors defined them as the LSP, which, without any physical means, develops a customized supply for its customers by mobilizing resources and resorting to different partners; then making sure of its consistency thanks to a total control of information flows. In this way, their business is to design and sell global supply chain solutions through the coordination of the activities of carriers, storage operators, subcontractors, packaging companies, and other elements of the supply chain. The figure 2 represents the chain as it can be managed by the 4PL.

Christopher (2005) explains that the principle underlying the 4PL model is that due to the increasing complexity and globalization of modern logistics networks, capacity to manage networks probably do not exist in any company. Thus, a 4PL can be considered as the representative of a new category of players who act as an interface between producers, distributors, designers, and carriers.

The role of 4PL can be synthesized through the following points:
-Information transfer between the parent and local partners. Limit the delays trips required between a payer and provider.
-Adaptation planning
-Anticipation and management of the flows de-synchronization between production and distribution
-Establishment of a Supply Chain / Logistics department to manage sourcing activities in low-cost countries which minimizes and / or controls the adverse effects induced described previously.

As a synthesis, the paradigms of ''lean'' and ''agile'' combinations developed by Christopher and Towill, (2002) can be considered. Thus, if lead-times are long but

demand is predictable, then there is opportunity for the pursuit of "lean" type strategies, e.g. make or source ahead of demand in the most efficient way (which may be the case of sourcing in Asia for the standard products), and when demand is unpredictable but lead-times are short, then agile solutions will be required based upon rapid response (which may be the case of relocation and sourcing in close countries).
In sourcing in low-cost countries context, the competitive advantage may be gained from superior network structure configuration, superior network relations and superior co-ordination (Colotla et al., 2003).

5 CONCLUSION

The characteristics of sourcing in low-cost countries affect the operational supply chain performance and decrease the positive effects such as cost savings. Companies intending to do the sourcing in countries with low-cost must plan how to get the most out of the supply chain of low-cost countries.

Focusing on the textile sector, our analysis of the phenomenon of sourcing in low-cost countries allowed us to highlight the various product categories and their impacts on the life cycle products and the sourcing zone, and then to analyze the impact of distant sourcing on the overall performance of supply chain. Indeed, product and service quality, responsiveness, total supply chain costs are strongly and negatively impacted. In this background the question of performance arises.
The figure 4 summarizes the levers identified to move towards performance.

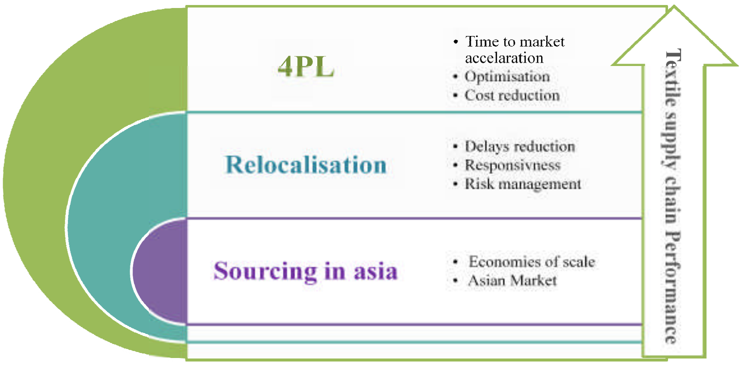


Figure 4: Globalization of sourcing and supply chain performance.

As mentioned in the article, sourcing in Asia still remains attractive despite the various problems identified. The result of this situation is that a part of production can be relocated in the Euro-Mediterranean zone and a part still sourced in Asia which must be managed by a 4PL provider able to coordinate and supervise sourcing operations. Indeed, integrating across enterprise boundaries serves an important role in ongoing performance improvement in the supply chain (Hammani et al., 2008).

Our approach is consistent with the findings published recently by Fine and Simchi-Levi (2010) to summarize the new Supply Chain design models in a context of globalization. The authors notes that the focus on cost reduction in supply chain management is one of the "most critical mistakes a company can make," and explores six emerging trends and forces that will bear on future ***supply chain*** design: ***globalization*** (long lead times); increasing logistics costs; increasing levels of risk; rising labor costs in developing countries; sustainability pressures; and marketplace volatility.

The originality of our research is the analysis of a general approach to the sourcing in low-cost countries costs problem. Some solutions through the comparison of theory to practice are proposed. Furthermore, managers must be aware of the problems inherent in the LLSC. Thus, this paper represents an analytical framework to describe the dimensions of the supply chain that may be affected by the sourcing in different regions in the world and their impact on the supply chain performance.

However, our research paper does face some limitations. The first is the lack of an empirical study. In fact, we relied on our experience in the industry and our theoretical and practical knowledge in supply chain management practices; however, interviews with textile companies who have chosen to outsource their business to low-cost countries or to relocate their businesses may lead us to find more explanations to this phenomenon.

The second limitation is the conceptual framework since some theories like internationalization theory, transaction costs theory and relational approach may be used in depth to explain this phenomenon. Future research may therefore be considered.

6 REFRENCES

Brannemo, A. (2006) "How does the industry work with sourcing decisions? Case study at two Swedish companies", *Journal of Manufacturing Technology Management* 17, 547-60.

Chopra, S., and P. Meindl (2004) "*Supply Chain Management: Strategy, Planning and Operations"*, Prentice-Hall.

Christopher, M. (2005) "*Logistics and Supply Chain Management: Creating Value-Adding Networks"*, Prentice Hall.

Christopher, M., and D. Towill (2001) "An integrated model for the design of agile supply chains", *International Journal of Physical Distribution & Logistics Management* 31, 235-46.

Colotla, I., Y. Shi, and M. Gregory (2003) "Operation and performance of international manufacturing networks", *International Journal of Operations & Production Management* 23, 1184 206.

Fine, C., and D. Simchi-Levi (2010) "The 6 forces driving supply chain design", *MIT Sloan Managment Review* 51, 18-21.

Fisher, M.L. (1997) "What is the right supply chain for your product", *Harvard Business Review* 75, 105-116.

Fredriksson, A., and P. Jonsson (2009) "Assessing consequences of low-cost sourcing in China", *Distribution & Logistics Management* 39, 227-249.

Fulconis, F., L. Saglietto, and G. Paché (2006) "Exploring new competences in the logistics industry: the intermediation role of 4PL", *Supply Chain Forum, an international Journal* 7, 68-77.

Garcia-Dastugue J.S., and D.M. Lambert (2007) "Différentiation retardée inter-organisationnelle dans la supply chain", *Journal of business logistics* 28, 31- 45.

Hammami R., Y. Frein, and A. Hadj-Alouane (2008) "Supply Chain Design in the delocalization context: Relevant features and new modelling tendencies", *International Journal of Production Economics* 113, 64-656.

Levy, D.L. (1995), "International sourcing and supply chain stability", *Journal of International Business Studies* 26, 343-60.

Lowson, R. (2002) "The implementation and impact of operations strategies in fast-moving supply systems", *Supply Chain Management: An International Journal* 7, 146-63.

Lowson, R.H. (2003) "Apparel sourcing: assessing the true operational cost", *International Journal of Clothing Science and Technology* 15, 335-45.

Moatti, V. (2008) "Low cost sourcing… or high cost supplying? Rencontres internationales de recherche en management stratégique", AIMS 2008. http://www.strategieaims.com/Aims08/aims08com/MOATTIV%20AIMS2008.pdf

Naylor, J. B., M. Naim, and D. Berry (1999) "Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain", *International Journal of Production Economics* 62, 107-108.

Pagh, J. D., and M.L. Cooper (1998) "Supply Chain Postponement and speculation strategy: how to choose the right strategy", *Journal of Business logistics* 19, 13-33.

Park J. H., and K.K. Seo (2004), " Incorporating life cycle cost into early product development", Engineering Manufacture 218, 1059-1066.

Rudberg, M., and J. Olhager (2003) "Manufacturing networks and supply chains: an operations strategy perspective", *Omega* 31, 29-39.

Slack, N., S. Chambers, and R. Johnston (2007) "*Operations Management*", Pearson Education.

REDESIGNING THE DEFENCE SUPPORT CHAIN

D Notman A Sinclair**, D Clegg**
*Sheffield Hallam University, UK,
**The Defence Support Group, Donnington, Telford, UK

ABSTRACT
Military operations are complex, difficult to support, and difficult to coordinate. As a consequence the organisations that have traditionally performed such operations were heavily structured, functionally organised and extraordinarily expensive to operate and maintain. Such monolithic structures are no longer considered to be economically viable. Major organisational reform, allied to evaluations of capability requirements and future role scenarios, has left western defence organisations significantly changed. Logistics support models developed in the civilian sector are being implemented in defence where there are significantly different sets of possible outcomes.

This paper outlines a case investigation of a major defence support organisation as it moved through this period of significant restructuring and change. It investigates the outcomes of a major support process redesign and discusses the impact of the changes for both the support organisation and the process being supported.

This case is part of a wider piece of research and the relationship between this support model and the current/future defence scenario are discussed.

INTRODUCTION
The research outlined in this paper investigates how and why a major Maintenance, Support and Overhaul (MRO) organisation has attempted to redesign it's support chain in order to reduce its cost base and improve its operational performance. The organisation operates in the defence sector and has seen significant changes in its demand requirement (supporting changing military operations) and its supply availability (a shrinking supplier base and a fragmented operational requirement)

The research was undertaken using a case based approach in order to establish an in-depth understanding of the organisational context and changes in the demand conditions. Cases are a commonly used method in both logistics research and in organisation specific studies (Dinwoodie & Xu, 2008; Stuart, et al, 2002; Voss, et al 2002). Establishing the generalisability of the findings is outside the scope of the work (and is in itself a methodological issue in case based work) but some indications for analysing a broader set of organisational support/supply chains are tentatively suggested (outside of the 'Lean versus Agile' debate (Mason-Jones, et al 2000; Vonderembse, et al 2006)).

BACKGROUND
Investigations of Supply Chain issues and the role of Supply Chains in delivering competitive advantage for organisations have become common within the logistics and operations management topic area (Burgess,et al, 2006; Sachan & Datta, 2005). While it is outside the scope of this paper to discuss this in detail, it is important to note that many industrial sectors have been investigated in depth in order to establish best (or at least good) practice in supply chain design and management practices. Two sub areas that have not received as much attention, however, are the chains associated with maintenance and support activities (Support Chains) and more specifically the Support Chain involved in the UK's defence sector (Dowdall, 2004; Graham & Hardaker, 1998; Ng et al, 2009). Support Chains are distinct from Supply Chains in that the products being distributed are also consumed/utilised within the operations of the process being supported. These products are usually required to support the Maintenance, Repair, and Overhaul (MRO) activities. As stated, the vast bulk of the literature available in this area relates to Supply rather than Support activities, but there are areas of significant commonality. From the an investigation of the Support/Supply Chain Literature we can see a number of factors relevant to the analysis of Support Chain design emerging:

Issues specific to maintenance and support processes

- Products must be designed and manufactured with support in mind but the support itself also represent a significant revenue generation opportunity for manufactruing and distribution companies (Markeset & Kumar, 2003; Cohen, et al 2000; Johnstone et al, 2009).
- The distribution and support activities can provide a significant competitive advantage for suppliers that support products being used in remote or safety critical environments (Markeset & Kumar, 2003)
- That changes in the use of the products have significant impacts on the product's maintenance needs and, therefore on the design of the support process. (Markeset & Kumar, 2003; Mathieu, 2001)

Issues specific to supply and support chain factors

- "The supply chain perspective is predicated on the fact that competition is shifting from firm versus firm to supply chain versus supply chain, and SCM is the approach to designing, organizing, and executing these activities". (Vonderembse, et al, 2006)
- The design of optimal Supply Chains should reflect the characteristics of the product and the characteristics of the demand (Singhal & Singhal, 2002; Vonderembse et al, 2006). One possible product categorisation is that of "Standard products" (stable demand, design characteristics, and volume requirements); "Innovative products" (new or derivative products aimed at new customers, designed to be adaptable to changing customer requirements); and "Hybrid products" (complex products, many components or technologies) (Vonderembse et al, 2006; Mason-Jones et all, 2000).

CHANGES IN THE DEMAND MARKET

In general, military equipment is specialised and produced in relatively small batches and relatively small volumes (Dowdall, 2004; Ng et al, 2009). The total size of the demand market is small and not open to free competition. This means that unit costs are high and that that the replacement intervals of equipment are long. As defence environments become more tightly cost controlled, the intervals are extending and the procurement budgets are migrating toward equipment maintenance, repair and overhaul activities.

A significant development in the last 10 years has been the changing resource requirement caused by variations in the operational demand. One example of this has been the difference in equipment requirement from early stage operations in Iraq where a mix of heavy and light armour (Challenger 2 tanks and Warrior APC's) predominated, to late stage Iraq operations and operations in Afghanistan where patrol and mobility became the priority. Initially this was done by fast and manoeuvrable Land rovers which proved to offer insufficient protection. As roadside Improvised Explosives Devices (IED's) became more widely used, the Landrover began to be replaced by heavier, wheeled armour that could better protect the soldier but still provide excellent mobility. These requirements developed quickly and were met by using Urgent Operational Requirements (UOR's) rather than the more normal multi-stage exhaustive procurement process (CADMID). While this 'short' UOR process has led to equipment reaching field operations much faster than 'normal' development and procurement cycles it has also led to a fragmented support chain with multiple new equipments being rushed into service without a planned support process. This example is also relevant because the heavy armour has been replaced in theatre but is still required for other possible future operations. This has led to Challenger 2 tanks being withdrawn from current operations but still being used (and supported) in training and planned maintenance operations. The complexity and range of operations and theatres of use mean that a flexible and adaptable support process is required (Hartley & MacDonald, 2010). However, financial pressures are forcing significant streamlining of support operations and the drift toward the adoption of availability based support and maintenance contracts provided by OEM's or third party suppliers (Johnstone,et al, 2009; Ng,et al 2009).

In summary, some of the key drivers for change in the defence market are:

- A level of unpredictability due to an ongoing requirement to support two medium scale operations, including the need to respond to a high level of Urgent Operational Requirements;
- Continuing pressure on Defence spending and affordability;
- An increasing requirement to demonstrate VfM ("best value for Defence");
- Growing international collaboration leading to system interoperability concerns;
- A continuing shift to Through-Life Capability Management (TLCM) and Industry Prime Contracting for both legacy and new equipment acquisitions and support solutions;
- The building by platform providers of strong industrial networks of partners that can provide "total solutions" that meet customer needs across all Defence Lines of Development (DLoD);
- Other key trends aligned to the delivery of the Defence Industrial Strategy (DIS). (Hartley & MacDonald, 2010)

THE EMERGENCE OF THE DEFENCE SUPPORT GROUP (DSG) AND IT'S SUPPORT CHAIN

The Defence Support Group (DSG) was formed in 2008, as a result of merging the Army Based Repair Organisation (ABRO – land based military systems) and the Defence Aviation Repair Authority (DARA – air based military system) trading funds. This merger followed the privatisation of some of the DARA business units and was based on the stated desire to reduce the combined overhead costs through shared infrastructure and economies of scale in operations. The goal of the combined organisation was to provide a flexible, responsive and operationally excellent organisation that was capable of delivering cost competitive maintenance overhaul, upgrade and repair (MORU) capability to both air and land systems of the UK armed forces. The service was required to support MOD operations at the Front Line (in a dangerous operations environment), and at specific locations throughout the UK, Canada and Germany (Second Line). The equipment supported ranged from mission critical to general support equipment and the organisation generates over £200 million pa in turnover.

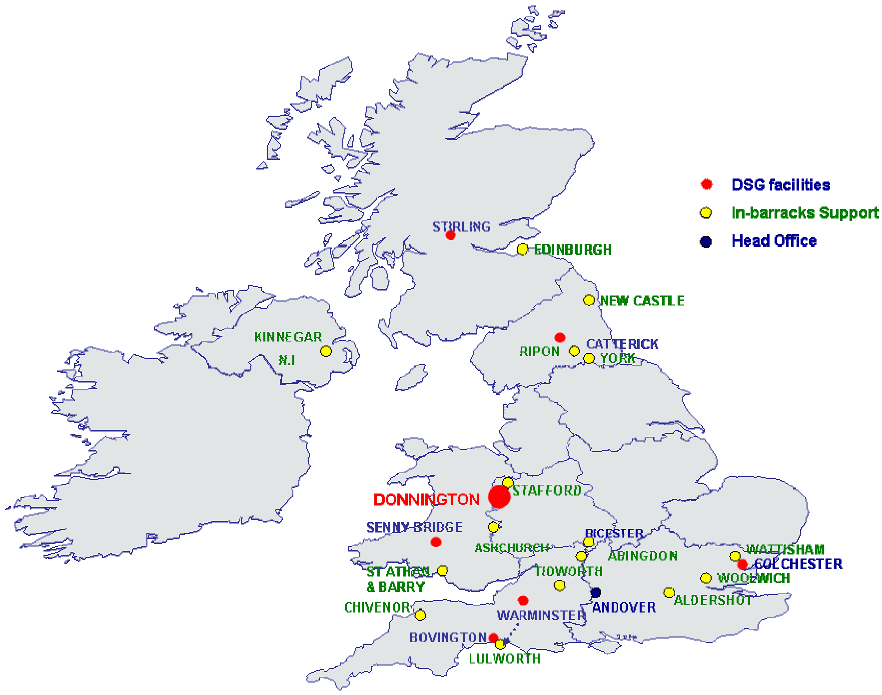
DSG capabilities range from strip, repair, replace and rebuild of large aircraft and main battle tanks, to the repair of assemblies and equipments such as Light vehicles and small arms equipment. This requires a complex set of technical capabilities, support equipment and components/materials be held, developed and deployed. All of these elements are expensive and time consuming to develop and hold. These activities are delivered within often complex and time critical customer requirements and expectations. As outlined earlier, these demand patterns are also becoming more fragmented in their geographical deployment and their volume requirement. Having merged the organisation, there was still felt to be a distinction between the two customer areas, Land and Air. For the purpose of this paper, the land sector of the business will be examined in more detail. MORU is a key part in the provision of cost effective through life capability management, aimed at extending the in service life of key equipment, encompassing small arms, electronics, electro optics, weapon systems, armoured fighting vehicles, light, medium and heavy trucks, recovery and high mobility vehicles. This service is provided in the UK through 7 regional workshops, and in order to extend the geographical coverage, DSG supplements military tradesmen with its skilled staff at 15 "In Barrack Equipment Support" (IBES) workshops, which primarily focus on rapid tasks such as fault diagnosis, servicing and minor repairs. The services offered by the larger workshops can include general service and repair, assembly of vehicles, technology insertions, remanufacture and diagnostics. The facilities also include a dedicated classified cryptographic unit for the repair of secure electronics, electro compatibility chambers capable of housing main battle tanks and a test facility for military automotive engines and transmissions.

LOCATIONS

A main driver behind the location decisions of DSG facilities was proximity to military garrisons (user groups) which provided a permanent requirement for particular regiments and their specific user generated requirements (Heavy armour etc). Specific regiments usually specialise in a particular aspect of military requirement, and consequently their requirements may be specific. This in turn has resulted in particular locations experiencing higher demand for specific vehicle types and their support activities.

Other contributors to the location of DSG distribution and support facilities were:

- The location of the OEM of equipment the army has purchased,
- other defence sites that have had available facilities for cooperation,
- Training sites (Salisbury plain, Jurassic coast) and logistics transportation features



UK map showing DSG locations

FORECASTABLE DEMAND

Telford and Bovington have high levels of armoured vehicle planned maintenance because of training bases close by using heavy equipment in a planned, forcastable manner. This planned maintenance work at both sites is managed through agreed schedules with 14 Integrated Project Team (IPT) equipment managers (the customer's representatives) and through approximately 1700 planned maintenance programmes. An annual schedule is produced and agreed between the workshop and IPT, vehicles are delivered to the site by the user, inspection of the vehicle takes place to identify any non-planned repair and a list of material required to affect the repair is generated. This is added to the list for the planned maintenance. The 1700 programmes use spares within the 45,413 SKU's which are active from a pool of over 100,000 SKU on file, and represents 65% approx of the DSG's turnover. Equipment turnaround times of approx 12 weeks are accepted by the customer as this equipment maintenance activity is scheduled between planned deployments on operations or training activities. This large number of SKU is supplied by some 500+ suppliers. 70 of these 500 vendors supplying 80% of the volume of the purchase orders placed p.a. To assist in the management of these parts, they have been segmented based on frequency of use and value. Annually there are approximately 80,000 purchase orders raised to acquire the 45,000 parts. With 7 workshops, 1500 shop floor staff all able to demand spares, and a high degree of "excessive demands" driven by experiential influences, where shop floor staff over demand "just in case" to potentially reduced waiting time, the quality of data arriving at the material planners can vary significantly.

INTERMITTENT DEMAND

Smaller workshops (Stirling, Catterick, Colchester, Warminster, Lulworth Cove, Sennybridge, Aldershot, and Kinnegar) all provide a reactive repair service to the whole of the Land forces for any equipment that develops a fault. The equipments concerned range from small electronics to small arms, motor bikes to Challenger tanks. Arrival rates and the nature and extent of repairs are random, notice of arrival ranges from no notice at all ('drive ins') to sailing schedules of ships returning damaged equipment from front line conflict. The contract with the customer is based on an urgency of need, and the processing lead time in this sector ranges from 72 hours for urgent operational requirements (UOR) to "by negotiation" with the local military chief liaison officers (MCLO). Aligned with each regional workshop are the IBES facilities which are effectively outposts of the workshops, utilising DSG employees and consuming DSG provided materials, supplied via DSG logistics facilities. This sector which covers in excess of 2000 products with original in-service dates ranging from 1970 through to current year, uses the same pool of parts as the planned maintenance sector, and represents 33 % of DSG turnover.

OPERATIONS FACTORS COMMON TO BOTH TYPES OF DEMAND

To support both types of demand, in an average year in excess of 500,000 individual pick, pack, and distribute activities take place. Where the main planned maintenance workshops specialise in a specific asset type, the stock is located at that facility, on the basis of the majority user has ownership and uses the logistics services to move parts internally to other demanding locations if the need arises. Many parts are used on multiple platforms or assets as this significantly reduces design costs at the early stage of planning the asset. As the ad-hoc element of the business is generally performed at all workshops, and all IBES locations, the central provisioning, storage and distribution centre (CPDC) provides an overnight delivery of items from the central stocks. Vendors deliver product either to the CPDC or appropriate workshop in line with MRPII generated demand notices.

For some parts a reverse supply chain is also provided. These parts are items where an OEM can refurbish items (brake shoes, alternators etc.) or major assemblies such as engines, gearboxes etc. Items are recorded on to the computerised stock control system and issued to specific workshops depending on the original demand requirement transaction initiated by the specific workshop, on an overnight delivery system. Incoming materials are affected through approx 100,000 receipt transactions annually. The workshops that perform the maintenance tasks in both areas described previously are primarily measured on labour efficiency achievement, within DSG it is described as direct labour utilisation (DLU). The Vendor base used by DSG is split by 33% from Society of Motor Manufacturers and Traders (SMMT) association members, and 66% from the Aerospace and Defence sector. The risks in the current economic environment to the 33% section are high, and having a consolidated approach based on selecting preferred vendors and entering in to non binding agreements to exclusively source specific categories of materials, has allowed increased levels of spend than would otherwise have been possible. Aligned with focussed supplier management activity, the risk to the downstream supply chain is mitigated. Further developments to reduce operating costs (and allow a focus on a reduced number of suppliers) centre on creating tier 1 suppliers which represent the 70 vendors supplying 80% of the volume of purchase orders (who manage the remaining 430 vendors).

THE SUPPORT CHAIN'S MAIN OPERATING OBJECTIVES

The prime objective of the support chain is to provide the user with their equipment on time. The changing demand environment outlined earlier is placing a greater emphasis on asset availability as asset numbers decrease but asset utilisation goes up. Any delay in providing spares has the effect of reducing user confidence in the whole process. This delay leads to "back robbing" a process commonly prevalent in MRO operations, where the required component is removed from the asset further back in the support process (in the expectation that when that asset requires the component at some point in the future it will be available). This leads to a loss of inventory visibility and to an inefficient distribution process.

DSG operates in an unusual environment where the materials costs are recovered through the contract with the customer meaning that component reliability and availability are more important than purchase price. There are many alternative sources for components that could be fitted to assets which could be purchased at a considerably lower cost than the purchase of OEM parts. Here the guarantee of access to the component outweighs the purchase cost. It should be noted, however, that this practice is coming under considerable pressure as cost containment and reduction become widespread in the sector.

WHAT CAN WE LEARN ABOUT SUPPORT CHAIN DESIGN?

Support chains (based on the supply of time critical, safety critical components and services) differ significantly from supply chains delivering components into manufacturing systems (Rao & Goldsby, 2009). At best, a support chain breakdown will reduce asset availability, at worst it will endanger life. The criticality of the support activity places a huge emphasis upon the durability and accuracy of the support chain's design (Chappell & Peck, 2006). The 'traditional' military model was based on 'organic capability', what we would normally refer to as direct control of all aspects of the support process implementation process. The model outlined above attempts to reduce inventory overlap and increase utilisation through a reduction in overall functional footprint (Fan, et al, 2010).

The factors highlighted earlier in the paper regarding product categorisation and demand segmentation are essential to a clear understanding of the interconnected, complexity of a major organisation's supply and support chain. Turbulence in the operations arena (demand market) can cause a reactive short term response that causes disaggregation of the support process into equipment (product) specific threads. This threatens to undermine the very rationale for developing such approaches in the first place, that the OEM's / suppliers can deliver a lower cost/higher performing service. If the complexity of the operational environment leads to a plethora of solutions providers an increase in coordination complexity is likely to cause an increase in support risk (with the knock on effect on operational performance).

The defence support chain is constantly exposed to significant turbulence. This turbulence can be extreme fluctuations in demand or supply exposure through supplier leverage issues (relatively small, intermittent demand). The reliance upon suppliers is increasing because of fewer tier 1 suppliers (as a result of aggregating demand and supplier generated spares provision). Similarly, these suppliers are providing a wider range of niche equipments rather than the narrow but deep production runs of traditional defence systems. The resilience issue depends upon close integration of information systems with suppliers and specifically coordination of supply /transportation activities. At its core, recent changes in the DSG's support chain raise significant questions about the risks associated with disaggregated support provision. This is particularly current as many support intensive market sectors have moved to supplier provided/availability based support contacts. Of relevance is the increased operational complexity created by such multi-thread support chains. DSG is attempting to manage this by creating a structure within which such approaches can be incorporated but it is yet to be seen whether this will prove to be a workable architecture within which the benefits of supplier provided support can be maintained as the sheer number of equipments being supported increases.

BIBLIOGRAPHY

Burgess, K., Singh, J, P., & Koroglu, R. (2006). Supply chain management: a structured literature review and implications for future research. *International Journal of Operations & Production Management* , 703-729.

Chappell, A., & Peck, H. (2006). Risk management in military supply chains: Is there a role for six sigma? *International Journal of Logistics: Research and Applications* ,
Cohen, M., Cull, C., Lee, H., & Willen, D. (2000). Saturn's supply chain innovation: high value in after sales service. *Sloan Management Review* , 93-101.

Dinwoodie, J., & Xu, J. (2008). Case studies in logistics: a review and tentative taxonomy. *International Journal of Logistics Research and Applications* , 393–408.

Dowdall, P. (2004). CHAINS, NETWORKS AND SHIFTING PARADIGMS: THE UK DEFENCE INDUSTRY SUPPLY SYSTEM. *Defence and Peace Economics* , 535–550.

Fan, C., Fan, P., & Chang, P. (2010). A system dynamics modeling approach for a military weapon maintenance supply system. *International Journal of Production Economics* , 457–469.

Graham, G., & Hardaker, G. (1998). Defence sector Procurement and Supply Chain Relationships. *Supply Chain Management* , 142–148.

Hartley, K., & MacDonald, P. (2010). COUNTRY SURVEY XXI: THE UNITED KINGDOM. *Defence and Peace Economics* , 43–63.

Johnstone, S., Dainty, A., & Wilkinson, A. (2009). Integrating products and services through life: an aerospace experience. *International Journal of Operations & Production Management* , 520-538.

Markeset, T., & Kumar, U. (2003). Design anddevelopment of product support and maintenance concepts for industrial systems. *Journal of Quality in Maintenance Engineering* , 376-392.

Mason-Jones, R., Naylor, B., & Towill, D. (2000). Lean, agile, or leagile? Matching your supply chain to the marketplace. *International Journal of Production Research* ,

Mathieu, V. (2001). Product services: from a service supporting the product to a service supporting the client. *Journal of Business & Industrial Marketing* , 39-58.

Ng, I., Maull, R., & Yip, N. (2009). Outcome-based contracts as a driver for systems thinking and service-dominant logic in service science: Evidence from the defence industry. *European Management Journal* , 377– 387.

Rao, S., & Goldsby, T. J. (2009). Supply chain risks: a review and typology. *The International Journal of Logistics Management* , 97-123.

Sachan, A., & Datta, S. (2005). Review of supply chain management and logistics research. *International Journal of Physical Distribution & Logistics Management* ,

Singhal, J., & Singhal, K. (2002). Supply chains and compatibility among components in product design. . *Journal of Operations Management* , 289–302.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R., & Samson, D. (2002). Effective case research in operations management: a process perspective. *Journal of Operations Management* , 419–433.

Vonderembse, M. A., Uppal, M., Huang, S. H., & Dismukes, J. P. (2006). Designing supply chains: Towards theory development. *International Journal of Production Economics* , 223–238.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations and Production Management*

EFFECT OF GETTING BACKHAUL LOADS IN LONG-DISTANCE TRANSPORTATION

Akihiro Watanabe [*1]
Keiichi Sato [*2]
Keizo Wakabayashi [*3]
Yu Fujita [*4]

[*1] Professor of Eng., Nihon University, Japan
[*2] Professor and Dr. of Eng., Hokkai School of Commerce, Japan
[*3] Professor and Dr. of Eng., Nihon University, Japan
[*4] Professor and Dr. of Eng., SANNO University, Japan
e-mail: wakabayashi.keizou@nihon-u.ac.jp

ABSTRACT
In Japan, there are a lot of load finding services through the Internet. However, truckload carriers do not have clear criteria of decision making about getting backhaul loads. We have presented a simple backhaul model connecting 3 points. We clarified the criteria of decision making along the model. And we found that a criterion of load efficiency contributed to the reduction of CO2 emissions and the increase of contribution margins. In this study, we generalize our logic with a simple backhaul model connecting 6 points. The model includes highway interchanges. Moreover, we execute a numerical experiment in long-distance transportations. As a result of the experiment, we reconfirm that a criterion of load efficiency contributes to the reduction of CO2 emissions and the increase of contribution margins.

INTRODUCTION
Many truckload carriers pay attentions to backhaul loads as means to improve their load efficiencies, because the backhaul loads can decrease negative environmental impacts and increase carrier's profits. In Japan, the decrease of the load efficiencies is a serious problem as the number of small amounts of truckloads is increasing. As one of solutions, there are a lot of load finding services through the Internet. However, truckload carriers do not have clear criteria of decision making about getting backhaul loads.

We have presented a simple backhaul model connecting 3 points: a starting point, a destination point and a backhaul pickup point. And we clarified the criteria of decision making about getting backhaul loads along the model (Fujita et al., 2007). Moreover, we executed a numerical experiment according to the criteria. As a result of the experiment, we found that a criterion of load efficiency contributed to the reduction of CO2 emissions and the increase of contribution margins (Watanabe et al., 2008).

In this study, we generalize our logic with a simple backhaul model connecting 6 points: a starting point, a highway interchange 1, a highway interchange 2, a destination point, a backhaul pickup point and a backhaul destination point. And we clarify a criterion of load efficiency along the model. After that, we confirm the effect of getting backhaul loads from a numerical experiment in long-distance transportations.

CRITERION OF GETTING BACKHAUL LOADS

[1] Simple Backhaul Model Connecting 6 Points
To clarify the criterion of load efficiency, we present the simple backhaul model in long-distance transportations as illustrated in Figure 1. The following conditions are assumed in the model.

$$\begin{aligned} n &> 0 \\ 0 < t_{01} &\leq n \end{aligned} \qquad (1)$$

$$(2)$$

$$0 < t_{23} \leq n \quad (3)$$

$$k_{01} > 0 \quad (4)$$

$$k_{23} > 0 \quad (5)$$

$$e_{12} \geq 0 \quad (6)$$

$$e_{30} \geq 0 \quad (7)$$

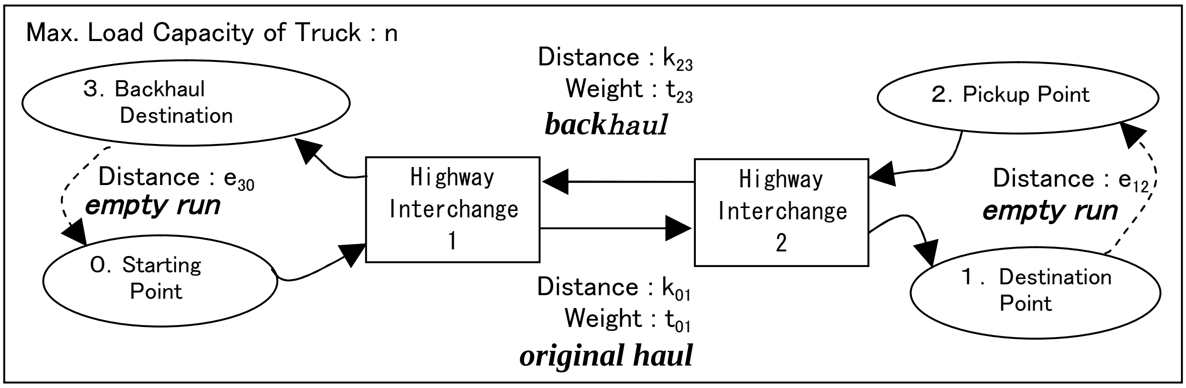


Figure 1: Simple backhaul model

[2] Criterion of Load Efficiency

In Japan, the Ministry of Land, Infrastructure and Transport issues the Annual Survey on Motor Vehicle Transport every year. In this report, freight ton kilometers and ability ton kilometers are announced (Ministry of Land, Infrastructure and Transport, 2009). The ability ton kilometer is the freight ton kilometer that assumes the case where a truck always runs at a maximum capacity loading. It is general that the load efficiency is calculated by the following computational expression (8).

$$\text{lord efficiency} = \frac{\text{freight ton kilometer}}{\text{ability ton kilometer}} \quad (8)$$

When a truck is shuttling in the starting point and the destination point without any backhaul loads, the load efficiency is expressible like the following expression (9) from Figure 1.

$$\frac{t_{01}k_{01}}{2nk_{01}} \quad (9)$$

On the other hand, the load efficiency with the backhaul load is expressible like the following expression (10) from Figure 1.

$$\frac{t_{01}k_{01} + t_{23}k_{23}}{n(k_{01} + e_{12} + k_{23} + e_{30})} \quad (10)$$

A total empty distance in one transportation TED is expressible like the following expression (11) from Figure 1.

$$TED = e_{12} + e_{30} \quad (11)$$

When the backhaul load is secured, a condition that improves the load efficiency is expressible like the following expression (12) from the expressions (9), (10) and (11).

$$\frac{t_{01}k_{01}}{2nk_{01}} < \frac{t_{01}k_{01} + t_{23}k_{23}}{n(k_{01} + k_{23} + TED)} \quad (12)$$

Moreover, the expression (12) can be transformed into the following expression (13).

$$TED < \left(\frac{2t_{23}}{t_{01}} - 1 \right) k_{23} + k_{01} \quad (13)$$

In addition, we try to show a backhaul distance and the total empty distance based on an original haul distance. A backhaul distance ratio BDR and an empty distance ratio EDR are expressed by the following expressions (14) and (15), respectively.

$$BDR = \frac{k_{23}}{k_{01}}$$

(14)

$$EDR = \frac{TED}{k_{01}} \quad (15)$$

In addition, we try to show a backhaul weight based on an original haul weight. A backhaul weight ratio BWR is expressed by the following expression (16).

$$BWR = \frac{t_{23}}{t_{01}} \quad (16)$$

The expression (13) can be transformed into the following expression (17) from the expressions (14), (15) and (16).

$$EDR < (2BWR - 1) BDR + 1 \quad (17)$$

In the criterion of load efficiency, the decision making about getting backhaul loads is done based on the expression (17).

NUMERICAL EXPERIMENT

To confirm the effect of getting backhaul loads in long-distance transportations, we executed the numerical experiment that followed the Monte Carlo method based on uniform distributions. Fundamental data of the experiment were decided depending on actual data of Japanese truckload carriers in 2007, because only that data could be obtained from various statistical materials. As a result of the experiment, the backhaul loads brought the increase of the contribution margins and the reduction of the CO2 emissions.

[1] Experimental assumption

Distance

In Japan, transportations between the Chubu region and the Kanto region are especially active. Under the circumstances, the Komaki IC and the Atsugi IC were the important highway interchanges used most frequently by truckload carriers in 2000 and 2005 (Ministry of Land, Infrastructure and Transport, 2007). Therefore, the Highway Interchange 1 and 2 in Figure 1 were assumed to be the Komaki IC and the Atsugi IC, respectively. In addition, the distances from the highway interchange 1 to the starting point and to the backhaul destination point were both assumed to be in the range of the distance from the Port of Nagoya to the Komaki IC. Similarly, the distances from the highway interchange 2 to the destination point and to the pickup point were both assumed to be in the range of the distance from the Atsugi IC to the Port of Yokohama. Each distance was determined as shown in Table 1 and the geographical coverage of the simple backhaul model was shown in Figure 2.

Route	Distance [km]
Port of Nagoya - Komaki IC	31
Komaki IC - Atsugi IC	332
Atsugi IC - Port of Yokohama	35

Table 1: Distance

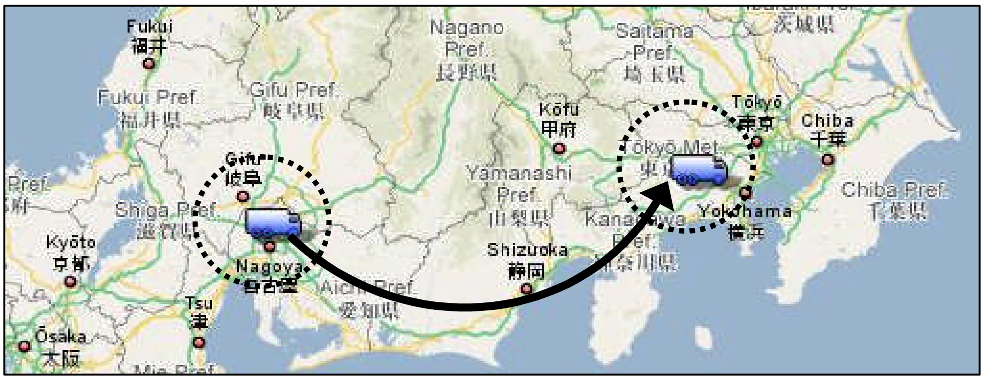


Figure 2: Geographical coverage of model

Truck

From the Report on Number of Automobile Possession According to Various Classifications, it was realized that 4t trucks were used most frequently in 2007 (Automobile Inspection & Registration Information Association, 2008). Therefore, the use of the 4t truck was assumed in the experiment.

To calculate CO2 emissions, mileages of trucks are needed. They vary with gross weights of trucks. The Ministry of Land, Infrastructure and Transport announced mileage targets by the gross weights of the trucks (Ministry of Land, Infrastructure and Transport, 2005). Data to make the targets covering a gross weight range of the 4t truck and their regression line could be illustrated as shown in Figure 3.

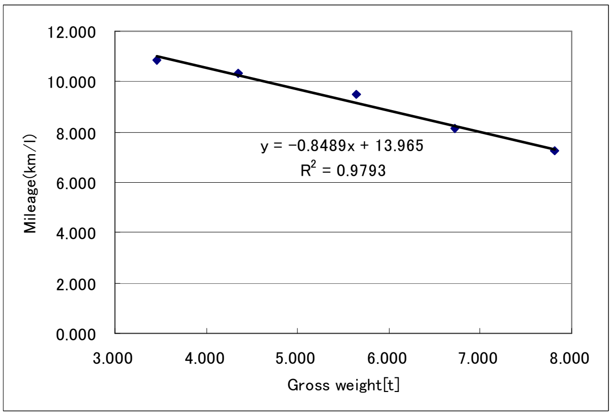


Figure 3: Mileage of 4t truck

From the regression line in Figure 3, it was assumed that the mileage of the 4t truck is calculated by the following computational expression (18).

$$mileage = -0.8489 \times \ gross\, weight + 13.965 \qquad (18)$$

In addition, it was assumed that the gross weight is the total of truck's body weight and loading weight. The experiment was executed using the 4t truck that had a standard body weight of 3.5 t.

Contribution Margin

In managerial accounting, contribution margins are recognized as the differences between sales amounts and variable costs amounts. Net profits are the differences between contribution margins and fixed costs amounts (Ghosh et al., 1988). Therefore, almost all managers always do efforts to increase the contribution margin.

In many cases, truckload carrier's sales amount is obtained from the freight charge that varies only with an actual haul distance. In the Report on Actual Freight Charges, average freight charges for the 4t truck in 2007 were determined by the following Table 2 (Editorial Department of LOGI-BIZ, 2010).

Actual haul distance [km]	Charge [yen]
0< and =<20	13,750
20< and =<50	17,161
50< and =<100	23,401
100< and =<150	27,542
150< and =<200	30,729
200< and =<300	39,347
300< and =<400	47,699
400< and =<500	55,511

Table 2: Freight charge for 4t truck

In the experiment, it was assumed that the truckload carrier's sales amount for one of the transportations could be determined by the Table 2.
On the other hand, it was assumed that truckload carrier's variable costs amount varies linear with a travel distance. In the experiment, a variable costs amount per unit of travel distance in 2007 was assumed to be 111.04 yen/km as shown in Table 3.

Item	Amount [yen/km]
Fuel expense	22.45
Road tolls	10.10
Maintenance and repairs	6.78
Variable driver costs	71.71
Total	111.04

Table 3: Variable costs amount per unit of travel distance

The data in Table 3 based on announcement in the Management Index Report on Motor Vehicle Transport (Automobile Business Association of Japan, 2009). In particular, the variable driver costs amount was calculated to be 48% of a whole driver costs amount according to a material provided by the Japan Trucking Association (Japan Trucking Association, 2008).

CO2 Emission

The CO2 emissions in the experiment were calculated using the mileage method presented by the Japan Institute of Logistics Systems (Japan Institute of Logistics Systems, 2006). The mileages for the original haul, the backhaul and the empty run were calculated by the computational expression (18). A CO2 emission coefficient was assumed to be 2.62 kg-CO2/l.

[2] Experimental Procedure

The following steps were executed for the numerical experiment.

Step-1: With aids of Microsoft Excel, 6 data based on the uniform distributions were generated as shown in Table 4. One transportation was consisted of a group of these data. Each distance range was based on the distances in Table 1.

Item	Range
Original haul distance(k_{01})	332.00 km 〜 398.00 km
Empty distance(e_{12})	0.00 km 〜 70.00 km
Backhaul distance(k_{23})	332.00 km 〜 398.00 km
Empty distance(e_{30})	0.00 km 〜 62.00 km
Original haul weight (t_{01})	0.01 t 〜 4.00 t
Backhaul weight(t_{23})	0.01 t 〜 4.00 t

Table 4: Experimental data

Step-2: 200 groups of data were generated. They composed 200 transportations as a sample. 3 samples were obtained according to this procedure.

Step-3: The 3 samples were made to correspond to each case as shown in Table 5. For each case, 200 contribution margins, freight ton kilometers and CO2 emissions were calculated.

Case 1	The truck always runs without any backhaul loads and shuttles between the starting point and the destination point.
Case 2	The truck runs with the backhaul load or shuttles without any backhaul loads depending on the criterion of load efficiency.
Case 3	The truck runs with the backhaul load in case where the contribution margin increases. In the other case, it shuttles without any backhaul loads.

Table 5: Case of transportation

EXPERIMENTAL RESULT AND DISCUSSION

[1] Contribution Margin

The sample mean values and standard deviations of the contribution margins were shown in Table 6, and the 95% confidence intervals of the mean values were shown in Figure 4. To confirm the statistically significant difference of the mean values, multiple comparison procedures were considered. The Games-Howell pairwise comparison test was executed with aids of SPSS, because the means had unequal variances (Games et al., 1976). This result was shown in Table 7.

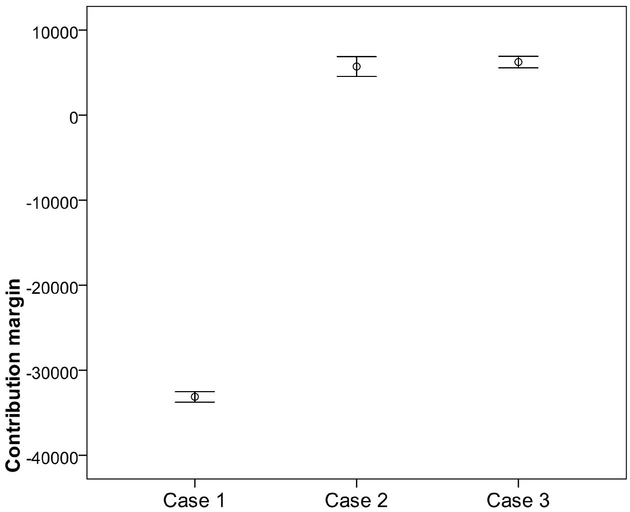


Figure 4: 95% confidence interval of mean value (contribution margin)

Case	Mean	Std. Deviation
1	-33123.29	4352.273
2	5724.98	8329.029
3	6252.36	4900.751

Table 6: Contribution margin [yen]

Pair		Difference	Significance Probability
(I)	(J)	(I - J)	
1	2	-38848.27**	< 0.010
1	3	-39375.65**	< 0.010
2	3	-527.38	0.721

Table 7: Multiple comparison (contribution margin)

From Figure 4 and Table 7, we confirmed that the case using the criterion of load efficiency (Case 2) and the case based on the contribution margin (Case 3) both increased the contribution margins compared with the case of no backhaul load (Case 1). However, we could not confirm the statistically significant difference between Case 2 and Case 3. If these cases have the same effect to increase the contribution margins, the criterion of load efficiency is the useful criterion because of its easiness of calculation.

[2] CO2 Emission

In Japan, many truckload carriers pay attentions to their CO_2 emissions per unit of freight ton kilometer as an environmental target (Japan Trucking Association, 2007). Therefore, those values were calculated in the experiment.

The sample mean values and standard deviations of the CO2 emissions per unit of freight ton kilometer were shown in Table 8, and the 95% confidence intervals of the mean values were shown in Figure 5. To confirm the statistically significant difference of the mean values, the Games-Howell pairwise comparison test was executed with aids of SPSS. This result was shown in Table 9.

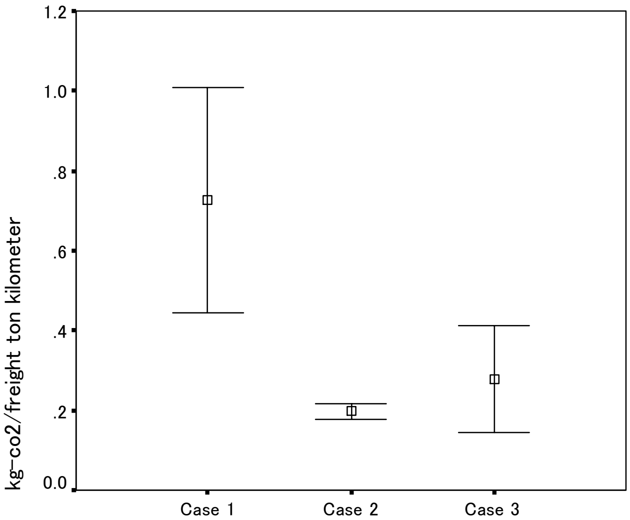


Figure 5: 95% confidence interval of mean value (CO2 emission)

Case	Mean	Std. Deviation
1	0.7268	2.01346
2	0.1977	0.14518
3	0.2783	0.94972

Table 8: CO2 emissionper unit of freight ton kilometer [kg-CO2]

Pair		Difference	Significance Probability
(I)	(J)	(I - J)	
1	2	0.5291**	< 0.010
1	3	0.4486*	0.013
2	3	-0.0806	0.463

Table 9: Multiple comparison (CO2 emission)

From Figure 5 and Table 9, we confirmed that the case using the criterion of load efficiency (Case 2) and the case based on the contribution margin (Case 3) both decreased the CO2 emissions per unit of freight ton kilometer compared with the case of no backhaul load (Case 1). However, we could not confirm the statistically significant difference between Case 2 and Case 3. If these cases have the same effect to decrease the CO2 emissions per unit of freight ton kilometer, the criterion of load efficiency is the useful criterion because of its easiness of calculation.

In addition, Figure 5 showed that the variance of Case 2 was extremely small compared with other cases. It is likely that the truckload carriers get stable CO2 emissions using the criterion of load efficiency.

CONCLUSIONS

In this paper, we presented the simple backhaul model connecting 6 points. And we clarified the criterion of load efficiency along the model. After that, we executed the numerical experiment in long-distance transportations using the model. As the result of the experiment, we confirmed the following points.

1) The case using the criterion of load efficiency and the case based on the contribution margin both increase the contribution margins compared with the case of no backhaul load.
2) We can not confirm the statistically significant difference of the contribution margins between the case using the criterion of load efficiency and the case based on the contribution margin.
3) The case using the criterion of load efficiency and the case based on the contribution margin both decrease the CO2 emissions per unit of freight ton kilometer compared with the case of no backhaul load.
4) We can not confirm the statistically significant difference of the CO2 emissions per unit of freight ton kilometer between the case using the criterion of load efficiency and the case based on the contribution margin.
5) The truckload carriers probably get stable CO2 emissions using the criterion of load efficiency.

Therefore, we think that the criterion of load efficiency is a good criterion to get the effect of getting backhaul loads because of its easiness of calculation.

ACKNOWLEDGMENT
This work was supported by KAKENHI(21530442) from the Ministry of Education, Culture, Sports, Science and Technology. The authors would like to acknowledge the support.

REFERENCES

Automobile Business Association of Japan (2009) Management Index Report on Motor Vehicle Transport, Automobile Business Association of Japan, Tokyo, pp.128-129.

Automobile Inspection & Registration Information Association (2008) Report on Number of Automobile Possession According to Various Classifications, Automobile Inspection & Registration Information Association, Tokyo, pp.438-439.

Editorial Department of LOGI-BIZ(2010) Report on Actual Freight Charges, Editorial Department of LOGI-BIZ, Tokyo, pp.132-133.

Fujita, Y., Wakabayashi, K., Karasawa, Y., Watanabe, A. and Osawa, K. (2007) "Decision Making about Getting Backhaul Load and Improvement of Load Efficiency for Truckload Carriers", International Journal of Logistics and SCM Systems, Vol.2, No.1, pp.12-21.

Games, P. A., and Howell, J. F. (1976) "Pairwise Multiple Comparison Procedures with Unequal N's and/or Variances: A Monte Carlo Study", Journal of Educational Statistics, Vol.1, No.2, pp.113-125.

Ghosh, P. K., Sharama, S. D. and Raj, G. D. (1988) Encyclopaedic Dictionary of Management, Anmol Publications, New Delhi, p.186.

Japan Institute of Logistics Systems (2006) CO2 Emissions Calculation Guide (Ver.2), (online), available from <http://www.logistics.or.jp/green/report/08_tool.html#co2_2007>, (accessed 2011-03-20).

Japan Trucking Association (2007) Mid-term Environmental Action Plan, (online), available from <http://www.jta.or.jp/kotsuanzen/tyuki/img/1812kankyo_pamph.pdf >, (accessed 2011-03-20).

Japan Trucking Association (2008) Current Status of Wage on Truckload Carrier, (online), available from <http://www.jta.or.jp/rodotaisaku/chingin/chingin_21/03.html >, (accessed 2011-03-20).

Ministry of Land, Infrastructure and Transport (2005) Final Report of Fuel Efficiency Target by Gross Weight, (online), available from <http://www.mlit.go.jp/kisha/kisha05/09/091110_.html>, (accessed 2011-03-20).

Ministry of Land, Infrastructure and Transport (2007) National Physical Distribution Census, (online), available from <http://www.mlit.go.jp/seisakutokatsu/census/census-top.html >, (accessed 2011-03-20).

Ministry of Land, Infrastructure and Transport (2009) Annual Survey on Motor Vehicle Transport, (online), available from <http://www.mlit.go.jp/k-toukei/06/annual/index.pdf>, (accessed 2011-03-20).

Watanabe, A., Wakabayashi, K., Karasawa, Y. and Fujita, Y.(2008) "Criteria of Getting Backhaul Loads for Truckload Carriers", Proceedings of the 13th International Symposium on Logistics, pp.603-608.

GLOBAL SUPPLY NETWORK OPTIMIZATION BY LOCATING PRODUCTION AND DISTRIBUTION FACILITIES IN THE FREE TRADE ZONE

Jun-Der Leu, Yu-Tsung Huang, Min-Hui Chen*
Department of Business Administration, National Central University
Jhongda Rd. 300, 32001 Jhongli, Taiwan

ABSTRACT
Global supply network configuration involves the issue of deployment of production and distribution facilities to different geographical locations. A Free Trade Zone (FTZ) is a special economic zone which provides the advantages of operation efficiency as well as financial benefits so that an international business can apply to optimize its supply network. However, the deployment of business sites to such an area necessitates the re-design of supply network and also requires the decision support analysis. In this research, we develop an economics evaluation model for the international business using the FTZ. In this model the material-flows, resources capacity, tariffs, import quota are well considered. This developed model is applied to the FTZ in Taiwan, while the international businesses can utilize this model to evaluate the effectiveness of their supply network using the FTZ.

Purpose:
Development of a decision support model for the evaluation of the economic advantage of global supply network configuration using Free Trade Zone(FTZ).

I. INTRODUCTION

When an international business configures its global supply network, a variety of factors need to be considered such as costs, resources, ports, regulations, political issues, and so on [1]. Many global businesses design their supply network considering economic regulations. Free Trade Zone (FTZ) is one of these economic regulations. FTZ is a special economic area wherein an international enterprise can deploy their resources of warehousing, packaging, the inspection, labeling, exhibition, assembly, fabrication, or trans-shipment [2, 3]. An air-cargo FTZ is one type of FTZ which allows improved operational efficiency to an international business specializing in high value-added products and emphasizing the time-to-customer requirement. These advantages allow an international business to deliver their products and services more efficiently and impact the decisions to manufacture locally or to rely on foreign imports [4].

In this research, we study the supply network configuration problem for an international business using an air-cargo FTZ. First, we develop a mixed integer linear programming (MILP) model of the global supply network configuration. Then, we develop a simulation model for considering the dynamic problem. The MILP and simulation models are applied to evaluate the benefits of the air-cargo FTZ application. Finally, some management insights are discussed. In the next section, a review of the global supply network configuration is presented. In section 3 the decision model is explained. In section 4 the simulation model is described while in section 5 the application of the air-cargo FTZ by an international business is discussed. Finally in section 6 the conclusions and directions for further research are noted.

II. LITERATURE REVIEW

Issues that need to be considered in the configuration of a supply network include market development, location decisions, supplier selection, business partner collaboration, process integration, etc [5]. In the past, these configuration problems have been solved using mathematical programming approaches [6, 7]. Bhutta *et al.* [8] studied global supply network decisions considering tariffs and exchange rates. They developed an MILP model to solve this type of problem and discussed several scenarios with different levels of exchange rates and tariffs. Avittathur *et al*. [9] developed a non-linear mixed integer model for business network configuration and used it to derive some suggestions for how the Indian government could best utilize taxes to reduce the logistic inefficiencies of Indian enterprises. These studies provide decision models for global supply network configuration, without the consideration of economic regulations. Wilhelm *et al*. [10] however, developed an MILP model that took into consideration North American Free Trade Agreement (NAFTA) applications. However, they did not consider a dynamic environment. Lee *et al*. [11] applied optimization and simulation approaches to deal with strategic problems in supply networks. They also applied a simulation approach to design, evaluate and optimize supply networks.

III. DECISION MODEL

We formulate the decision problem as a MILP model: In the global supply network configuration, the capacity refers to production factories, distribution centers are considered. These capacities can be deployed in the normal industrial area or in the FTZ. We decide the location of distribution centers and select suitable suppliers. The company headquarters obtains demand orders from the given marketing channels worldwide, and the distribution centers assembly and distribute final products to the market. These final products are assembled from semi-finished products and components. Semi-finished products are provided by foreign up-stream manufacturers, named front-end factories and components are provided by foreign component suppliers. Each supplier provides only one kind of component modules or materials. Beside the facility capacity, in the basis model we also consider the capacity of transportation service providers, materials supply, the cost in terms of production, assembly, materials acquisitions, transportation, exchange rates, tariffs and so on. The indices, parameters, decision variables and constraints are described below.

- **Indices**

f index of semi-fished product supplier $\{1, 2, 3,\dots, f,\dots, F\}$

n index of component supplier $\{1, 2, 3,\dots, n,\dots, N\}$

w index of distribution center $\{1, 2, 3,\dots, w,\dots, W\}$

r index of semi-fished product $\{1, 2, 3,\dots, r,\dots, R\}$

k index of component $\{1, 2, 3,\dots, k,\dots, K\}$

p index of final product $\{1, 2, 3,\dots, p,\dots, P\}$

c index of channel $\{1, 2, 3,\dots, c,\dots, C\}$

- **Parameters**

AD_{pc} demand for product p from channel c

J_{pw} quantity of final product p at distribution center w

Q_{rfw} quantity of semi-finished product r from semi-finished product supplier f to distribution center w

Q_{knw} quantity of component k from component supplier n to distribution center w

Q_{pwc} quantity of final product p from distribution center w to channel c

CF_{rf} supply capacity of semi-finished product r from semi-finished product supplier f

CN_{kn} supply capacity of component k from component supplier n

U_{rp} required quantity of semi-finished product r for final product p

U_{kp} required quantity of component k for final product p

S_r unit transportation capacity for semi-finished product r

S_k unit transportation capacity for component k

S_p unit transportation capacity for final product p

LM_{fw} transportation capacity from semi-fished product supplier f to distribution center w

LM_{nw} transportation capacity from component supplier n to distribution center w

LM_{wc} transportation capacity from distribution center *w* to channel *c*
V_{pw} unit production capacity for final product *p* at distribution center *w*
DIS_{fw} distance from semi-finished product supplier *f* to distribution center *w*
DIS_{nw} distance from component supplier *n* to distribution center *w*
DIS_{wc} distance from distribution center *w* to distribution center *w* to channel *c*
SC_{w} set-up cost of distribution center *w*
OC_{w} operating cost of distribution center *w*
FC_{fw} fixed transportation cost from semi-finished product supplier *f* to distribution center *w*
FC_{nw} fixed transportation cost from component supplier *n* to distribution center *w*
FC_{wc} fixed transportation cost from distribution center *w* to channel *c*
PC_{rfw} unit transportation cost for semi-finished product *r* from semi-finished product supplier *f* to distribution center *w*
PC_{knw} unit transportation cost for component k from component supplier *n* to distribution center *w*
PC_{pwc} unit transportation cost of final product *p* from distribution center *w* to channel *c*
MC_{pw} unit manufacturing cost of final product *p* at distribution center *w*
Y_{rfw} unit procurement cost of semi-finished product *r* from semi-finished product supplier *f* to distribution center *w*
Y_{knw} unit procurement cost of component *k* from component supplier *n* to distribution center *w*
Y_{pwc} unit price of final product *p* from distribution center *w* to channel *c*
TAX_{rfw} tariffs on semi-finished product *r* from semi-finished product supplier *f* to distribution center *w*
TAX_{knw} tariffs on component *k* from component supplier *n* to distribution center *w*
TAX_{pwc} tariffs on final product *p* from distribution center *w* to channel *c*
GC_{w} customs clearance cost for distribution center *w*
E_{f} exchange rate of currency for country of semi-finished product supplier *f*
E_{n} exchange rate of currency for country of component supplier *n*
E_{w} exchange rate of currency for country of distribution center *w*
E_{c} exchange rate of currency for country of channel *c*
TRFC total fixed transportation cost
TRVC total variable transportation cost
TOC total operating cost of distribution center
TMC total manufacturing cost
TPC total procurement cost
TTAX total tariffs
TGC total customs clearance cost

- **Decision variables**

CW_{pw} capacity of final product *p* in distribution center *w*

X_w 1, distribution center *w* is selected; 0, else

A_w 1, distribution center *w* operates; 0, else

B_{fw} 1, semi-finished product supplier *f* provides distribution center *w*; 0, else

Z_{nw} 1, component supplier *n* provides distribution center *w*; 0, else

A_{wc} 1, distribution center *w* provides channel *c*; 0, else

- **Constraints**

Distribution centers need to arrange the shipment of final products to channels in (1) and (2). In it, M symbolically presents a huge positive number. In this process, the quantity of final products at the distribution centers must be greater than the demand quantity of the channels in (3) and (4).

$$A_{wc} \times M \geq Q_{pwc}, \forall p, w, c \quad (1)$$

$$A_w - A_{wc} \geq 0, \forall w, c \quad (2)$$

$$J_{pw} \geq \sum_c Q_{pwc}, \forall p, w \quad (3)$$

$$\sum_w Q_{pwc} \geq AD_{pc}, \forall p, c \quad (4)$$

Transportation costs include fixed and variable ones in (5) and (6). The transportation costs from semi-finished product suppliers to distribution centers, form component suppliers to distribution centers and form distribution centers to channels are all considered.

$$TRFC = \sum_w \sum_f FC_{fw} \times E_f \times B_{fw} + \sum_w \sum_n FC_{nw} \times E_n \times Z_{nw} + \sum_c \sum_w FC_{wc} \times E_w \times A_{wc} \quad (5)$$

$$TRVC = \sum_w \sum_f \sum_r PC_{rfw} \times DIS_{fw} \times Q_{rfw} \times E_f \quad + \sum_w \sum_n \sum_k PC_{knw} \times DIS_{nw} \times Q_{knw} \times E_n$$

$$+ \sum_c \sum_w \sum_p PC_{pwc} \times DIS_{wc} \times Q_{pwc} \times E_w \quad (6)$$

Assembly assignments are only executed in the operating distribution centers (7). The capacity restrictions of distribution centers are considered in (8).

$$A_w \leq X_w, \forall w \quad (7)$$

$$V_{pw} \times J_{pw} \leq CW_{pw}, \forall p, w \quad (8)$$

Total operating costs of distribution center include both set-up and operating costs (9).

$$TOC = \sum_w SC_w \times E_w \times X_w + \sum_w OC_w \times E_w \times A_w \quad (9)$$

Total manufacturing costs are summarized from manufacturing costs in all distribution centers (10).

$$TMC = \sum_{w} \sum_{p} MC_{pw} \times J_{pw} \times E_{w} \tag{10}$$

The transportation quantity of semi-finished products and components are restricted in (11) and (12). The transportation capacity restrictions of semi-finished product suppliers, component suppliers and distribution centers are considered and presented in (13), (14) and (15).

$$B_{fw} \times M \geq \sum_{r} Q_{rfw}, \forall f, w \tag{11}$$

$$Z_{nw} \times M \geq \sum_{k} Q_{knw}, \forall n, w \tag{12}$$

$$LM_{fw} \geq \sum_{r} Q_{rfw} \times S_{r}, \forall f, w \tag{13}$$

$$LM_{nw} \geq \sum_{k} Q_{knw} \times S_{k}, \forall n, w \tag{14}$$

$$LM_{wc} \geq \sum_{p} Q_{pwc} \times S_{p}, \forall w, c$$

(15)

The supply capacity of semi-finished product suppliers and component suppliers is considered in (16) and (17). The procurement quantity of semi-finished products and components has to be satisfied with distribution centers in (18) and (19).

$$\sum_{w} Q_{rfw} \leq CF_{rf}, \forall r, f \tag{16}$$

$$\sum_{w} Q_{knw} \leq CN_{kn}, \forall k, n \tag{17}$$

$$\sum_{f} Q_{rfw} \geq \sum_{p} U_{rp} \times J_{pw}, \forall w, r \tag{18}$$

$$\sum_{n} Q_{knw} \geq \sum_{p} U_{kp} \times J_{pw}, \forall w, k \tag{19}$$

There are procurement costs for semi-finished products and components. The calculation of total procurement costs is presented in (20).

$$TPC = \sum_{w} \sum_{f} \sum_{r} Y_{rfw} \times Q_{rfw} \times E_{f} + \sum_{w} \sum_{n} \sum_{k} Y_{knw} \times Q_{knw} \times E_{n} \tag{20}$$

When semi-finished products and components are transported between countries, there are tariffs to pay (21). Customs clearance costs are necessary when distribution centers are not locate in an FTZ (22).

$$TTAX = \sum_{w} \sum_{f} \sum_{r} TAX_{rfw} \times Q_{rfw} \times Y_{rfw} \times E_{w} + \sum_{w} \sum_{n} \sum_{k} TAX_{knw} \times Q_{knw} \times Y_{knw} \times E_{w}$$

$$+ \sum_{c} \sum_{w} \sum_{p} TAX_{pwc} \times Q_{pwc} \times Y_{pwc} \times E_{c} \tag{21}$$

$$TGC = \sum_{w} GC_w \times E_w \times A_w \qquad (22)$$

All 0, 1 variables are presented in (23).

$$X_w, B_{fw}, A_w, A_{wc} \in \{0,1\} \qquad (23)$$

The objective function is to minimize total costs, including transportation costs, operating cost, manufacturing cost, tariffs and customs clearance costs (24).

$$Min \quad TOC + TPC + TMC + TRFC + TRVC + TTAX + TGC \quad (24)$$

IV. SIMULATION METHOD FOR THE STOCHASTIC BEHAVIOUR OF THE GLOBAL SUPPLY NETWORK

The simulation model starts from the demand orders. The initial input is the from the results of MILP model. The simulation model is developed by eM-Plant software, which includes 11 sections: customer orders, capacity of semi-finished product supplier, distribution of semi-finished product supplier, transportation form semi-finished product supplier to distribution center, capacity of component supplier, distribution of component supplier, transportation form component supplier to distribution center, distribution center, distribution of distribution center, transportation form distribution center to channel, channel, and so on. The simulation model is illustrated by Figure 1.

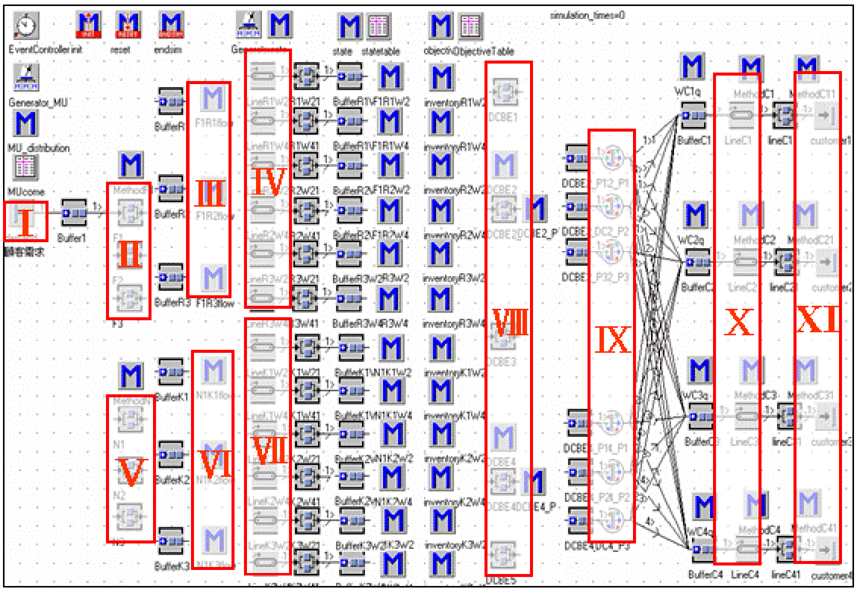


Fig. 1. eM-Plant simulation model of the global supply network

- I: Demand management: Demand orders. Orders from each marketing channel are designated by lot size with a normal distribution. The average lot size is applied to estimate the total demand. The total demand is applied to estimate the customer orders. The average is $\frac{\sum_t \sum_c \sum_p \overline{Q}^t_{pwc}}{simulation\ hours}$; the standard deviation is $\frac{\sigma_{\overline{Q}} \bullet C \bullet P}{simulation\ hours}$.
- II: Capacity of semi-finished product supplier. The capacity of semi-finished product supplier is calculated by $\frac{\sum_r CF_{rf}}{simulation\ hours}$.

- III: Material-flows refer to the distribution of semi-finished products suppliers and distribution centres.
- IV: Transportation from semi-finished product supplier to distribution center. The supply lead time of semi-finished product from supplier *f* to distribution center *w* is viewed as constant, $LTfw_{fw}$.
- V: Capacity of component supplier: The capacity of the semi-finished product supplier is calculated by $\frac{\sum_k CN_{kn}}{simulation\ hours}$.
- VI: Distribution of component supplier. The material-flows of components between component suppliers and distribution centers are controlled in this section.
- VII: Transportation form component supplier to distribution center. The supply lead time of component from supplier *n* to distribution center *w* is viewed as constant, $LTnw_{nw}$.
- VIII: Distribution center. The cycle time of assembly is viewed as constant, LT_{pw}. The capacity of distribution center is calculated by $\frac{CW_w}{simulation\ hours}$.
- IX: The control mechanism of material-flows of final products from distribution centers to market channels.
- X: Transportation from distribution center to channel. The supply lead time of final product from distribution center *w* to channel *c* is viewed as constant, $LTwc_{wc}$.
- XI: The material-flows from the distribution centres to market channels worldwide.

The results obtained from the decision model, which is solved by Lingo 8.0, are collected and form the initial inputs of the simulation model. This shortens the simulation time.

V. AN APPLICATION CASE

The case company is a global electrical and electronics manufacturing enterprise that assembles and distributes three kinds of final products (P1, P2 and P3) to channels in Europe, America, China and Japan (C1, C2, C3 and C4). All final products are manufactured by distribution centers in America and Europe (DC+BE1 and DC+BE3). The European distribution center (DC+BE3) serves all channels while the American distribution center (DC+BE1) serves the channels in America (C2) and Japan (C4). For procurement, the case company has front-end factory for semi-finished product in China (F1), America (F2) and Taiwan (F3). It also has component suppliers in China (N1), Thailand (N2) and Mexico (N3). In terms of operations, the semi-finished products are provided by the supplier in Taiwan (F3) and components are provided by the supplier in Thailand (N2). Figure 3 presents the logistics map of the case company.

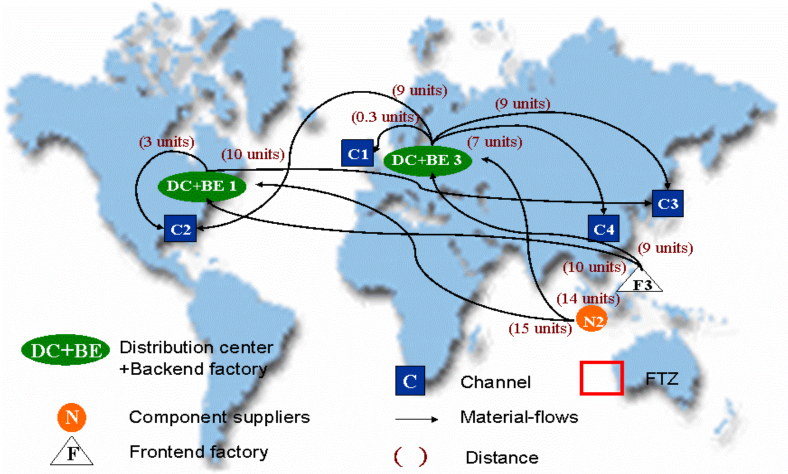


Fig. 2. Original global supply network of the case company

The case company considers time-to-market requirements, It evaluates the effectiveness of the FTZ application in Taiwan (DC+BE2), Europe (DC+BE4) and Korea (DC+BE5). These FTZs offer simplified customs clearance procedure, convenient transportation infrastructure, and tariff reduction. In addition to a distribution center, the case company also evaluates front-end factory in China (F1) and America (F2) as well as component suppliers in China (N1) and America (N3). It expects to re-configure the optimal supply network to include FTZ applications.

- **Calculation results**

After calculation, the MILP model results show total costs of $16,003,400 while the simulation model results show $16,263,372 (50 simulation run, standard deviation 43,252). This is a 1.7% difference and indicates the feasibility of these two models.

The results show the changed optimal supply network. The new supply network is presented in Table I and illustrated in Figure 4. Case company selects distribution centers in Taiwan (DC+BE2) and Europe (DC+BE4) in its new supply network. Both of these distribution centers are located in air-cargo FTZs. Within this framework, the distribution center in Taiwan (DC+BE2) serves channels in America, China and Japan (C2, C3 and C4); the distribution center in Europe (DC+BE4) serves channels in Europe and America (C1 and C2). For procurement, it selects component suppliers and semi-finished product suppliers from China (N1 and F1). In this new supply network configuration, the transport distance is decreased from 81.3 units to 40.3 units. The case company also decreases costs by 22.5%. This means that reconfiguration of the global supply network to include the application of air-cargo FTZs improves the performance.

TABLE I Global supply network before and after FTZ application

Cost Items	AS-IS	TO-BE	Difference
Manufacturing cost	$1,097,323	$1,503,910	-37.1%
Transportation cost	$6,834,712	$2,796,399	59.1%
Procurement cost	$7,291,262	$7,236,064	0.8%
Inventory cost	$56,613	$54,569	3.6%
Tariffs	$4,750,881	$4,780,045	-0.6%
COGS	$949,565	$1,055,578	-11.2%

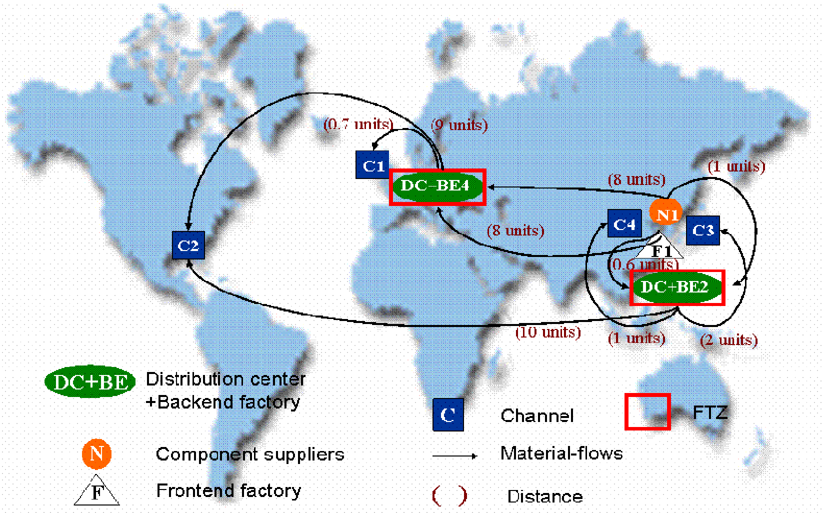


Fig. 3. Global supply network after the reconfiguration

VI. CONCLUSIONS AND FURTHER RESEARCH

In this research, we proposed a MILP-based decision model for the economic evaluation of air-cargo FTZs. We also consider a dynamic environment and develop a simulation model. The application case demonstrates the feasibility of these two models. The results show changes in the global supply network after consideration of air-cargo FTZ application. It also allows the enterprise to take the advantages of operational efficiency and financial benefits. These models provide an approach to economic evaluation that can be used by international businesses who would like to apply air-cargo FTZs. They can assist senior managers with decisions about production and distribution allocation, purchase of raw materials and network configuration. In fact, there are several different scenarios for FTZ application. These scenarios are suitable for different businesses and require specific evaluation models. This can be a direction for future research.

REFERENCES

[1] C.-S. Lu, C.-H. Liao, and C.-C. Yang, "Segmenting manufacturers' investment incentive preferences for international logistics zones", *Int. J. Oper. Prod. Manage.*, vol. 28, no. 2, pp. 106-129, 2008.
[2] P.S. Tansuhaj and J.W. Gentry, "Firm differences in perceptions of the facilitating role of foreign trade zones in global marketing and logistics", *J. Int. Bus. Stud.*, vol. 18, no.1, pp. 19-33, 1987.
[3] P.S. Tansuhaj and G.C. Jackson, "Foreign trade zones: a comparative analysis of users and non-users", *J. Bus. Log.*, vol. 10, no. 1, pp. 15-30, 1989.
[4] W.G. Kanellis, "Reining in the foreign trade zones board: making foreign trade zone decisions reflect the legislative intent of the foreign trade zones", *Northwestern J. Int. Law Bus.*, vol. 15, no. 3, pp. 606-635, 1995.
[5] H. Stadtler and C. Kilger, *Supply Chain Management and Advanced Planning: Concepts, Models, Software, and Case Studies*. Berlin Heidelberg: Springer-Verlag, 2008.
[6] J.F. Shapiro, *Modeling the Supply Chain*. California: Thomson Learning Inc., 2007.
[7] S.H. Owen and M.S. Daskin, "Strategic facility location: a review". *Eur. J. Oper. Res.*, vol. 111, no. 3, pp. 423-447, 1998.
[8] K.S. Bhutta, F. Huq, G. Frazier, and Z. Mohamed, "An integrated location, production, and investment model for a multinational corporation". *Int. J. Prod. Econ.*, vol. 86, no. 3, pp. 201-216, 2003.
[9] B. Avittathur, J. Shah and O.K. Gupta, "Distribution centre location modeling for differential sales tax structure". *Eur. J. Oper. Res.*, vol. 162, no. 1, pp. 191-205, 2005.
[10] W. Wilhelm, D. Liang, B. Rao, D. Warrier, X. Zhu, and S. Bulusu, "Design of international assembly systems and their supply chain under NAFTA". *Transp. Res. Part E*, vol. 41, no. 5, pp. 467-493, 2005.
[11] Y.H. Lee, M.K. Cho, and Y.B. Kim, "Supply chain simulation with discrete-continuous combined modeling". *Comput. Ind. Eng*, vol. 43, pp. 375-392, 2002.

THROUGH REDESIGN OF THE SUPPLY CHAIN NETWORK AND NEW INVESTMENTS TO MORE CONTAINERS - CASE STUDY OF THE PORT OF KOPER

Prof. Igor Trupac, Prof. Elen Twrdy*
Faculty of Maritime Studies and Transport, University of Ljubljana,
6320 Portorož, Slovenia

ABSTRACT
The growth of container traffic in the Port of Koper as well as the beginning of construction on the new container terminal has made the reconstruction and extension of the current container terminal an absolute priority. The extension is in line with the estimated growth of traffic as well as with the exploitation of present and future terminal capacities.

The year 2009 was a dificult year for business, especially due to the uncertain international economic situation. The container terminal handled 344,086 TEUs which is 3% less compared to 2008 (358,654 TEUs). In the first nine months of 2010, 16 % more goods were handled in the Port of Koper than in the same period in 2009. The container transport has especially exploded in tons (45% increase) as well as in container units (40% increase). Within this period they have handled 355,000 TEUs (new record) in the container terminal (214,000 TEUs in the same period on the seventh pier in Trieste).

This paper aims to present and analyse: (I) supply chains of the flow of containerised goods through the Port of Koper to/from the countries of Central and Eastern Europe (II) the changes which enable this boom, current state and strategies to handle even more containers in the future, (iii) market potential, current and future investments in new capacities.

INTRODUCTION
For the Port of Koper is the Central and Eastern Europe market very important. Many manufacturing companies especially major vehicle and also vehicle parts producers, but also many smaller ones as well have invested in the NMS (New Member States of Europe), partly following their main customers but also to take advantage of the qualified and cheap labour force for export production. This development has led to larger bi-directional East-West flow within the European Union of raw materials and consumer products. The traditional 'blue banana" is approaching the shape of a boomerang as a result of extensions to central and east Europe and significant investments in the Mediterranean (Notteboom 2009).

The global container transport increase amounts to about 8-10% on a yearly basis. According to BRS-Alphaliner (http//www.infomare.it) the entire number of newly constructed container ships should increase by 27%, the number of ships over 7500 TEU by up to 40% between 2005 and 2008. Ships of over 7500 TEU are to have a major influence on container terminals because these terminals will need to adjust their infrastructure and reconstruct their suprastructure. Today, ports should be conceived as logistics and distribution centres that not only optimise the movement of goods and services within the entire transport and logistics chain, but also provide and add value to ultimate customers and users (Bichou 2009).

THE PORT OF KOPER - MEMBER OF NAPA (NORD ADRIATIC PORTS ASSOCIATION)
The five NAPA seaports (ports of Koper, Trieste, Venice, Ravenna and Rijeka) are located at the northern tip of Adriatic sea, a natural waterway that penetrates deep into the middle of the European continent, thus providing the cheapest naval route from the Far East via Suez to Europe.

Figure 1 - Main transport corridors important for the NAPA seaports

Source: NAPA (www.portsofnapa.com)

More than 100 million tonnes of water-borne cargo are handled in the NAPA seaports every year. The cargo consists mainly of general cargo, containers, cars, ores and minerals, fossil fuels, chemicals and others types of cargo. Due to huge variety of logistic services and the extensive traffic network, NAPA forms a perfect multimodal gateway to the key European markets. The near-by fifth Pan-European transport corridor (Fig. 1) provides a quick-link to 500 million European consumers. Large commercial and industrial hubs like Vienna, Munich and Milan are just few hours drive away. The five entities combine their strengths in order to promote the Northern Adriatic route and present themselves as an alternative to the North-European ports. In addition, the association anticipates cooperation in the development of maritime and hinterland connections, visits from cruise lines, environmental protection, safety and information technology. (www.portsofnapa.com)

Table 1: Container transport of the North Adriatic Ports in the years 2007 – 2009 in TEUs

	2007	2008	2009
KOPER	305,648	353,880	343,165
TRIESTE	265,863	335,943	277,245
RIJEKA	145,040	168,761	130,740
VENEZIA	329,512	379,072	369,403
RAVENNA	206,580	214,324	185,022

Source: NAPA (www.portsofnapa.com)

Table 2: Comparison of Container Traffic in TEUs, 2009:

ROTTERDAM	9,743,290
ANTWERP	7,309,640
HAMBURG	7,007,704

NAPA PORTS	1,174,618
MARSEILLE	876,757

Source: www.portsofnapa.com

In addition to pursuing the intensive promotion of the southern gateway to the European continent, the Association is also active in national and European institutions which tailor European transport policy. Thanks to NAPA's efforts, the Adriatic-Baltic corridor (Fig. 1) was finally included among the nine high-priority corridors encompassed by the EU directive for the development of railfreight.

RECENT DEVELOPMENT OF THE CONTAINER TERMINAL

The container transport increase was of 400% in the years from 2000 to 2008. In 2008 there were 358,654 TEUs transported. Because a further increase in orders of ships of 7500 TEUs and over was expected (http//www.infomare.it, p.1) an extension of 146 m of the first pier began to be built so that the entire length of the coast amounts today to 596 m (Fig. 2). In 2009 the port gained two transtainers and four post – panamax cranes (Fig. 2) for transport with ships of 7500 TEUs capacity.

The annual transport capacity increased to 600,000 TEUs with the purchase of new storing bridge cranes with stacking capacity of 4 or 5 containers in height, the repositioning of empty containers to new locations and acquiring new areas for full containers by doing so and with faster working of containers from the ship to the terminal and vice versa.

Container terminal 2002

Container terminal 2010

Figure 2:Container terminal in the year 2002 and 2010

Source: Port of Koper

Connections of the container terminal

The terminal is connected with the Far East weekly with regular direct lines and through feeder service with important HUB ports in the Mediterranean (Malta, Piraeus, Gioia Tauro, Haifa) from where regular connections lead to all the continents of the world. As the maritime connection of the port is important so is also the so called land connection. In this way the Port of Koper is connected to important trade centres of the middle and east Europe by regular railway connections and the highway cross. The railway transport of containers out and into the container terminal of the Port of Koper is performed by six different transport companies. Today 7 block trains are daily executed from the Port of Koper to various destinations like: Ljubljana, Budapest, Žilina, Graz. The execution of road freight transport is left to the local transport companies.

The transport of containers in the year 2008 was 358654 TEUs, in the year 2009 – 344,086 TEUs and in the year 2010 – 476,731 TEUs (Tb.3). Despite the global recession the decline in container transport in the year 2009 was minimal. A great increase in transport followed in the year 2010 which was also a consequence of the introduction of the direct line between Asia and the north Adriatic.

Beside the great increase in transport also the portion of container import and export states is changing. The Slovenian portion in the entire transport is steadily decreasing, partly also because of the crisis in the Slovenian economy. The transport in transit is increasing, especially with Austria, Slovakia and the Czech Republic. The transport with Italy and Germany does not reach the desired growth. A lot of unexploited possibilities are still in the transport of goods with Germany or Bavaria and Austria because they perform the major part of their container transport through north European ports.

Table 3: Container transport in the Port of Koper in the years 2001 – 2010 in TEUs

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TEUs	93187	114863	126237	176458	212025	256265	303524	358654	344086	476731

Source: Port of Koper

Container services – direct services out/in Koper
The terminal connectedness is one of the key information for business partners. Regarding maritime routes the container terminal is connected with other ports and regions on the basis of 14 so called services.

We can separate the maritime connectedness into two categories namely to direct services from/to the Far East (such are two) and the rest of 12 services of which the ports are located in the Mediterranean. These services are also called “feeder” services because they visit among others also important Mediterranean HUB ports like Gioia Tauro, Malta, Piraeus, Haifa, Taranto, etc. from which maritime routes lead to all the continents of the world.

On figure 3 a newly implemented service (from June 2010 on) with the Far East is shown, which has been established together by four shipping companies namely Hanjin Shipping, Hyundai Merchant Marine, United Arab Shipping Company and Yang Ming Marine Transport Corporation. This is a very important service for the container terminal because it flourished in the crisis or post crisis period. In the aforementioned service eight different ships sail – two per each shipping company, which weekly visit the Port of Koper.

Figure 3: Newly implemented direct service with the Far East

Source: Port of Koper

The other direct service (Fig. 4) is performed by the shipping companies MAERSK LINE and CMA CGM. The container line between Asia and the north Adriatic is supplying markets in Slovenia, Slovakia, the Czech Republic, Austria, south Germany, Serbia, Bosnia and Herzegovina, Hungary and Croatia. The entire route takes 63 days. The ships capacities are from 6200 to 7000 TEUs.

The weekly service is maintained with 9 ships between 16 ports - Shanghai, Pusan, Hong Kong, Chiwan, Tanjug Pelepas, Port Kelang, Port Said, Trieste, Koper, Rijeka, Trieste, Damietta, Port Said , Suez Canal, Jeddah, Port Kelang, Singapore in Shanghai.

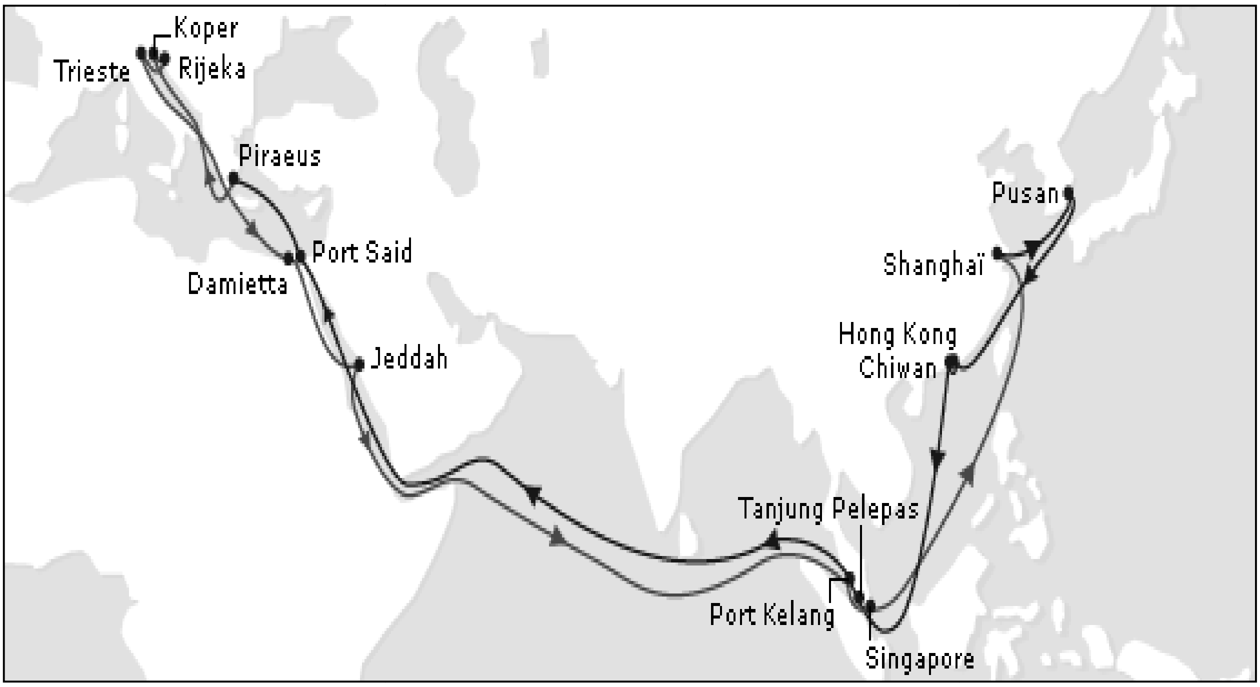


Figure 4: Newly implemented direct service with the Far East intended for the automobile industry

Source: http://www.cma-cgm.com/eBusiness/Schedules/LineServices/ServiceSheet.aspx?ServiceCode=BEX2

For the container business on this line that is intended for the automobile industry (JUST IN TIME) is typical that:

Freight comes from South Korea
Freight presents automobile parts destined to the "Kia" and "Hyundai" factory
It is approx. 140,000 TEUs on an annual level (approx. 1,250,000 tons of cargo)
It is 2 ship services (2x a week)
Containers have priority when unloading from ships holds
Freight "starts" from port in a few hours after unloading from the ship – certain containers even in 30 minutes!!!
The quantity increases from year to year and similar strategy is introduced also in other freights – electronics

Table 4: Container transport on the container terminal of the Port of Koper performed by the shipping companies (%)

CMA CGM	28,55
MAERSK	27,58
MSC	19,01
ZIM	7,41
HANJIN SHIPP.	4,71
HYUNDAI	3,40
EVERGREEN	2,32
HAPAG LLOYD	1,46
HDS LINES	1,40
COSCO	1,33
OTHER	2,83
TOTAL	100,00

Source: Port of Koper

CONDITION TO HANDLE EVEN MORE CONTAINERS IN THE FUTURE
In the future developmental possibilities are seen in the construction of the new third pier (Fig. 5) to be able to receive the latest container ships which are not presently able to dock on the pier one due to its shallowness. From the point of view of infrastructure the minimal standards to be met are 350 metres of shore, 14, 5 metres of sea depth as well as shore area capable of carrying »post-panamax« cranes. The construction of the third pier is planned to be caried out in two phases:
700 m of the quay area in length enabling transhipment of 800,000 TEU.
350 m in length (total 1050 m) enabling total transhipment of 1,000,000 TEU.

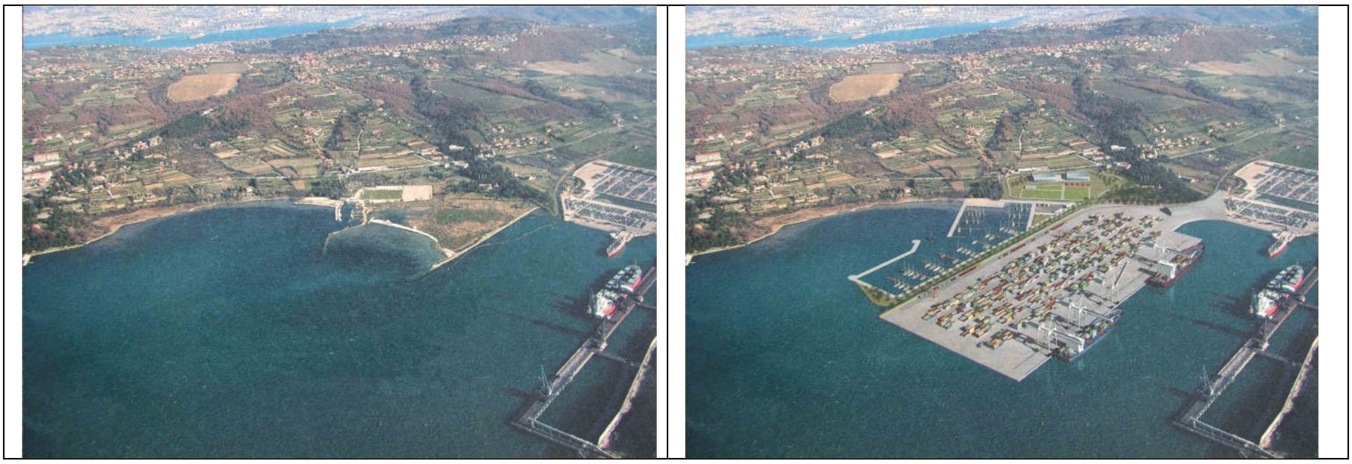


Figure 5: Present and the future Pier III

Source: Port of Koper

Today, whole supply chains are competing, not just ports among themselves. Ports are important elements in the logistics chain and their level of integration with inland transport is very important. Main reasons for this need is that costs for inland transport are generally higher than maritime transport costs and many delays can occur in the inland side of the chain such as congestion, limited infrastructure etc. The portion of inland costs in the total costs of container shipping would range from 40% to 80% (Notteboom 2004).

Moreover, there are some important developmental reserves as far as the effectiveness of railway transport is concerned. These should be brought about by the privatisation and by the restructuralisation of the sector itself, which can mostly be seen in the Central and Eastern European countries. For one thing, organising the so called »block trains« in the Adriatic basin is a strategy that hasn't been exploited to the fullest. In this respect the northern ports have the upper hand. In order for the Port of Koper to be able to load more container number of »blocks trains« should increase. In the near future modernisation of the Koper-Divača railway connection will increase cargo flow by 30%. The construction of the second railway track has a net worth of 700 Million Euro and forms a part of the Fifth Corridor from Lyon to Kiev, which puts it on the priority list of projects co-funded by the European Union.

Beside the aforementioned activities, the Port of Koper wishes to develop new activities from which the cooperation of the Port of Koper with existing inland terminals (logistic centres) and establishing of new ones positioned between eastern and western Europe stand out. The Adria Terminali (Sežana), regional logistics center "Panonija" (Lipovci), inland container hub-rail port Arad as well as Adria transport d.o.o. will give a strong support to the terminal activities in the Port of Koper providing efficient logistic solutions for south transport route (Fig. 6).

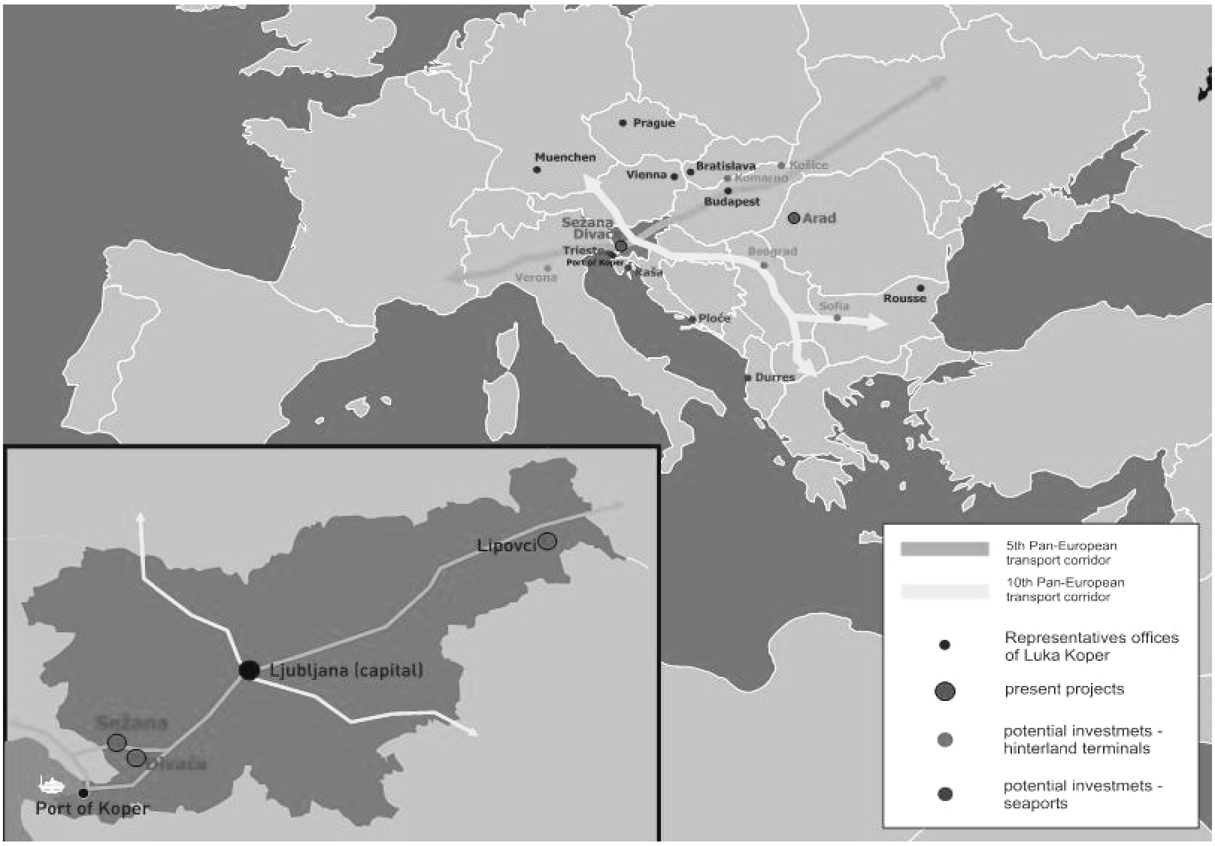


Figure 6 - Location of the Adria Terminali (Sežana), regional logistics center "Panonija" (Lipovci) and inland container hub-rail port Arad

Source: The Port of Koper

Terminals are the main regulators of freight flows and as such considerably influence the setting and operation of supply chains in terms of location, capacity and reliability (Jean-Paul Rodrigue & Theo Notteboom, 2008).

CONCLUSION

Today, the countries of Central and Eastern Europe (CEE) have developed into a fast growing and promising part of Europe. The vision of the NAPA seaports is to form a European logistics platform with regard to servicing these markets as well as the markets of the Far East. To obtain better service the ports of NAPA are going to invest efforts into the coordinated planning of road, rail and maritime infrastructure, as well as the harmonisation of regulations and procedures in the field of port service provision.

What is noticeable today is the obvious increase in orders of ships of over 7500 TEUs, which in turn means a larger margin for ship-owners sending their ships to transport containers on the main East-West, Asia-Europe, and Asia-North America routes. That's why the business orientation of the Port of Koper to develop principal infrastructure and acquire new business partners in the container transport area has proved to be correct. Great financial investments in the extension of the container shore, expansion of storing space and purchasing of specialized transport equipment has proved in the big increase in transport in the year 2010. Despite the global crisis the increase of transport was approx. 40%. The quantity of transported containers is reaching enviable numbers but the future growth is threatened. That is why construction of the third pier with 1 mill. TEUs capacity, a second railway track from Koper to Divača and the upgrade of the rest of the railway tracks in Slovenia is necessary.

New projects and potential investments are important steps within the development of the Port of Koper enhancing it's performance and increasing the market share.

REFERENCES

Bichou, K.: Lloyd's Practical Shipping Guides, Port Operations, Planning and Logistics, Informa Law, Mortimer House, London, 2009

Notteboom, T.: A carrier's perspective on container network configuration at sea and on land, Journal of International Logistics and Trade 1(2):65-87, 2004

Notteboom, T.: Economic analysis of the European seaport system – Report serving as input of the discussion on the TEN-T policy – 14 May 2009, ITMMA – University of Antwerp

Rodrigue, J.P., Notteboom, T.: The Terminalization of Supply Chains, IAME 2008, Dalian, 2008

Statistics of NAPA (www.portsofnapa.com)

Statistics of the Port of Koper (www.luka-kp.si)

The longterm strategy of the Port of Koper (Port of Koper), 2006

A NON-RIGID STRUCTURED SCHEDULING OF SHORT-HAUL PARCEL DELIVERY SERVICES

Iqbal Singh Johal and Ming K. Lim
School of Engineering and Applied Science, Aston University, United Kingdom
email: johalis@aston.ac.uk, m.k.lim@aston.ac.uk

ABSTRACT
The aim of this paper is to introduce a methodology to solve the short haul vehicle routing problem that is specific to the parcel service industry, without the need for rigid structures. The methodology proposed has three phases. The first phase constructs the compact core areas, which represent the majority of daily workload for each driver. The second phase defines the potential assignment of unscheduled requests to certain cores. In the final phase a Genetic Algorithm (GA) is used as a construction meta-heuristic to assign the unscheduled requests to the defined cores. It is envisaged that the methodology will generate high quality solutions by creating routes with the lowest combined vehicle route times, whilst sharing a more equitable workload.

KEYWORDS:
Delivery scheduling, short haul vehicle routing, genetic algorithm.

INTRODUCTION

Transportation adds value to a product by physically moving the product to where it is required. This added value is often referred to as space utility (Grant and Lambert, 2006). The most efficient mode of transport to deliver to any downstream end user is by mechanical road transport. Parcel Service Operators (PSOs) using this mode provide small package transportation services, which is a crucial part of national and international transportation (Golden et al., 2008).

The pickup and delivery costs for a PSO with full geographic coverage are estimated to be between 35-60% (Wasner and Zäpfel, 1998). Subsequently, PSOs require an efficient dispatching system. The system assigns workload and delivery routes to drivers, which enhance their performance, directly improving the overall service quality, as well as reducing the operating cost for the provider (Zhong, 2004).

Presently within the UK parcel service industry, short-haul transportation is scheduled using postal units or fixed driver areas designed using historical demand patterns**.** Neither of these are tailored to the spatial spread of requests. Due to the rigid nature of the current systems of scheduling, imbalances between driver workloads occur. In most cases rebalancing is undertaken by drivers with localised information, whom collectively amend the assignment to ensure feasibility.

The innovation in the parcel service industry has not focused on the area of transportation (Choudhry and Khan, 2001). Hence, the aim of this paper is to introduce a methodology to solve the short haul vehicle routing problem that is specific to the parcel service industry, without the need for rigid structures. Therefore, overcoming the inefficiencies of current practices, with the aim of reducing costs associated with operating the fleet for a longer duration and a potential need for additional service vehicles.

LITERATURE REVIEW

The interest in Vehicle Routing Problem (VRP) is motivated by both its practical relevance and its considerable difficulty (Toth and Vigo, 2002). The basic VRP involves the design of routes for delivery vehicles of known capacities, which operate from a central distribution centre, to supply a set of customers with known locations and known demands for a certain commodity. Routes for the vehicles are designed to minimise some objective, such as the total distance travelled. The VRP requires decisions on routing and assignment (Alonso et al., 2008). The solution process for the VRP is often split into two phases: solution construction and then solution improvement.

Solution Construction
In the construction phase, nodes or arcs are continuously grouped until a feasible solution has been created. There are two main types: sequential construction builds routes one after the other; parallel construction builds routes simultaneously with prior knowledge of the number of vehicles required (Braysy and Gendreau, 2005). Generally, previous research suggests that a parallel route construction method is superior to sequential method (Liu and Shen, 1999).

Well-known construction methods
One of the best known VRP sequential construction methods is the savings heuristic, first introduced by Clarke and Wright (1964). The initial solution assigns each request to an individual vehicle. Each route consists of a journey from the depot (0) to the request and back to the depot. The heuristics combines two routes serving requests i and j, if there is a saving (S) in the service cost (c), Sij = ci0 + c0j – cij (Braysy and Gendreau, 2005). The combining of routes is considered in descending order of savings. However, the combination is disregarded if a cycle of requests occur.

Gillet and Miller (1974) introduced a sequential construction method called the sweep heuristic for a VRP. Firstly, a polar axis is centred at the depot in the direction of a randomly selected request. From this a ray is rotated, continually adding requests to a vehicle in order of their polar angle, until either vehicle capacity or route distance constraint is satisfied. The next route is constructed in the same manner, commencing from the position of the previous ceased ray. This process continues until all requests have been routed. The routes are finally optimised using the well established Kernighan and Lin (1973) algorithm for the Travelling Salesman Problem. The sweep heuristic follows an exhaustive approach because all possibilities are exhausted by varying the angle of the polar axis. The solution with the lowest total routing time is accepted.

Solomon (1987) proposed several well known insertion heuristics and Insertion 1 (I1) a sequential construction heuristic, is the most successful (Braysy and Gendreau, 2005). A route is initialised by selecting a seed request to which unscheduled requests are iteratively assigned until no more feasible insertions can occur. This process is repeated for a new seed, until all requests have been assigned.

Potvin and Rousseau (1993) introduced a parallel construction heuristic based on the I1 heuristic. In contrast to Solomon (1987), the method considers a regret measure when considering the cost of insertion. The role of the regret measure is to prevent the postponement of difficult requests to the last iterations, where options become restricted (Pisinger and Ropke, 2007). The measure acts as a 'lookahead', by estimating the cost of not inserting a request instantly into their best route, instead to postpone the assignment for later.

Solution Improvement
The solution improvement phase is often referred to as a local search. This continually improves the initial solution by performing myopic neighbourhood moves, until a stopping criterion is met. The neighbouring solution is evaluated by the objective function and if desirable, normally in-terms of cost, replaces the current solution. The neighbouring solution will only differ in a few attributes from the current solution. Continuous application of a local search will result in a local optimum. However, this may be far from the optimal solution, as the quality of the local optimum depends substantially on the initial solution. A general conclusion exists in the literature for many problems of interest, local search algorithms can find good solutions in feasible running times (Aarts and Lenstra, 2003).

Well-known improvement methods
The most widely adopted local search technique for the VRP is the edge exchange, (Braysy and Gendreau, 2005). Introduced by Lin (1965), the technique exchanges k-arcs used to construct the route with a set of k-arcs outside the route. Where an arc connects two nodes and k equals the number of arcs referred to. This exchange is known as k-exchange or k-opt. If further k-exchanges are not possible, the route is referred to as k-

optimal. Exhausting all possible k-exchanges to verify k-optimal requires O(n^k) time. The k-opt operator changes the orientation of routes, therefore being not well adapted to routes with time windows (Garcia et al., 1996). Hindrance of k-opt on time windows resulted in Or (1976) introducing the Or-opt operator, which acts in the same way as k-opt, without modifying the orientation of the route. Consecutive requests are considered for exchange in the sequence: three; two; and one. The sequence must be spatially compacted and is either moved to a different location within the route, or to another neighbouring route. For each sequence, all insertion locations are considered (Garcia et al., 1996). Unlike the k-opt operator, which exchanges arcs belonging to the same route, Potvin and Rousseau (1995) introduced 2-opt* operator, which exchanges arcs between two different routes without changing their orientation. The operator only exchanges the last sequence of requests in each route, therefore ensuring time windows are satisfied. This operator should not be used if the initial route assignments are optimum (Potvin, 1995).

Savelsbergh (1992) proposed three inter-route operators: Relocate; Exchange and Cross. The Relocate operator removes a request from a route and places it into another, between two consecutive requests. The Exchange operator swaps requests between two different routes. Finally, the Cross operator tries to remove crossing arcs between routes, then swaps the end sequence of requests between the two routes.

METHODOLOGY

In this paper a three phase solution methodology for the static vehicle routing problem with deliveries and pickups among time windows is proposed. The solution is intended for the parcel service industry where a high density of non-bulk requests exists. Throughout each phase the scheduling of requests is based on the following objectives: guarantee service fulfilment within given time bounds; minimum total routing time of the fleet; and finally balanced workload between drivers, whilst always maintaining vehicle load feasibility. Five types of requests are considered for assignment in this paper, which can all be categorised into two main classes: standard or timed. The standard requests include: delivery (d), pickup (p), and simultaneous delivery & pickup (dp). Each must be serviced within the normal operating hours of the driver. However, the timed requests which include: timed delivery (dam); and timed simultaneous delivery & pickup (dpam), must be serviced within the upper time bound. No restrictions are placed on the drivers to service one type of request before another. The requests cannot be split between drivers and are limited to a single visit. Also, the requests are assigned to a uniform fleet, which operates during standard working hours. All vehicles must leave and return to the single distribution centre once a day.

The minimum number of vehicles required to service the region is based on the capacity requirements. Consequentially, route times may exceed the driver's operating hours, resulting in unfeasible solutions. In such a situation the fleet size will increase by one and the method described below will be repeated, until a feasible fleet size is obtained.

Phase 1 - Core Construction

The first phase constructs in parallel the compact core areas, which represent the majority of daily workload for each driver. The service requests allocated to each core have been proven to belong to no other driver. Figure 1 depicts 4 constructed cores in a region.

Step 1 – Create Buffers

Each request within the region will expand by an incremental radius creating a circular buffer around itself, assigning requests on and inside the boundary. The buffer represents a potential vehicle assignment, referred to as a core. Once the maximum number of requests are assigned, without exceeding the capacity of a vehicle, the buffer will cease to expand.

Step 2 – Routing Times

Using vehicle routing software, the route times for each buffer assignment, serviced from a single distribution centre will be calculated. All buffer route times that exceed the operating times of the driver will be disregarded. The remaining buffers will be sorted in order of route time length. The buffers with the lowest route times will represent the most compact assignments.

Step 3 – Core Selection
In turn, the buffer with the lowest vehicle route time will be selected as a core, until the number of cores equal the number vehicles required to service the region. However, no duplication of requests between cores is permitted. If a feasible solution cannot be obtained, Step 1 to 3 is repeated with a reduced vehicle capacity in Step 1, until the required number of drivers is obtained in Step 3. It is recommended to set the starting vehicle capacity lower than the actual vehicle capacity in Step 1, to avoid repeated unfeasibility.

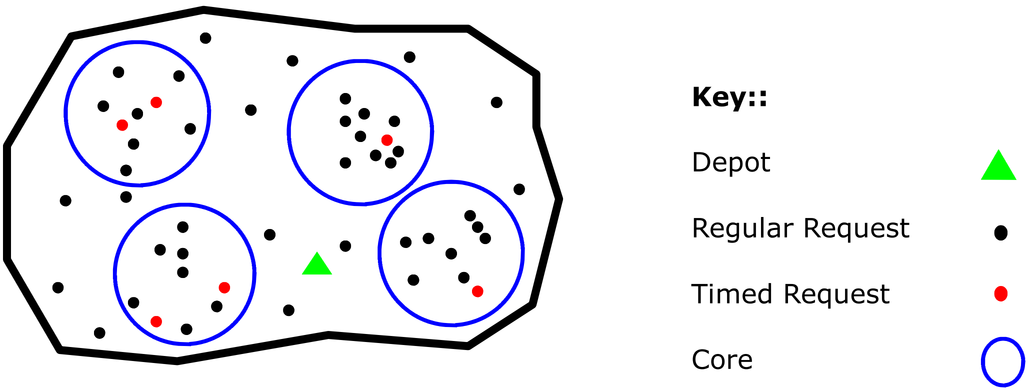


Figure 1 - Cores

Phase 2 – Define Potential Core Assignments
The second phase defines the potential assignment of unscheduled requests to certain cores. The output will be utilised predominantly in the next phase. However, all single overlapped requests are assigned in this phase.

Step 1 – Core Expansion
In parallel, each radius used to construct the cores, will incrementally expand by a fixed distance, until all unscheduled requests have been overlapped by at least one expanded core, as shown in Figure 2. The potential assignment of requests will be restricted to the overlapping core(s). However, this tight bound could affect the feasibility of the solution in phase 3 and may need to be relaxed by expanding the cores further.

Step 2 – Single Core Request
The request(s) overlapped by a single expanded core, will be assigned to the same core unless, the insertion proves to be capacity or route time unfeasible. In such cases, the core due for insertion will create sufficient slack by transferring their previously assigned request(s) to neighbouring cores. Alternatively, the request due for insertion will be assigned to another core. Both options are explored and the cheapest is selected. This construction process selects the single overlapped requests for assignment in a random sequential manner.

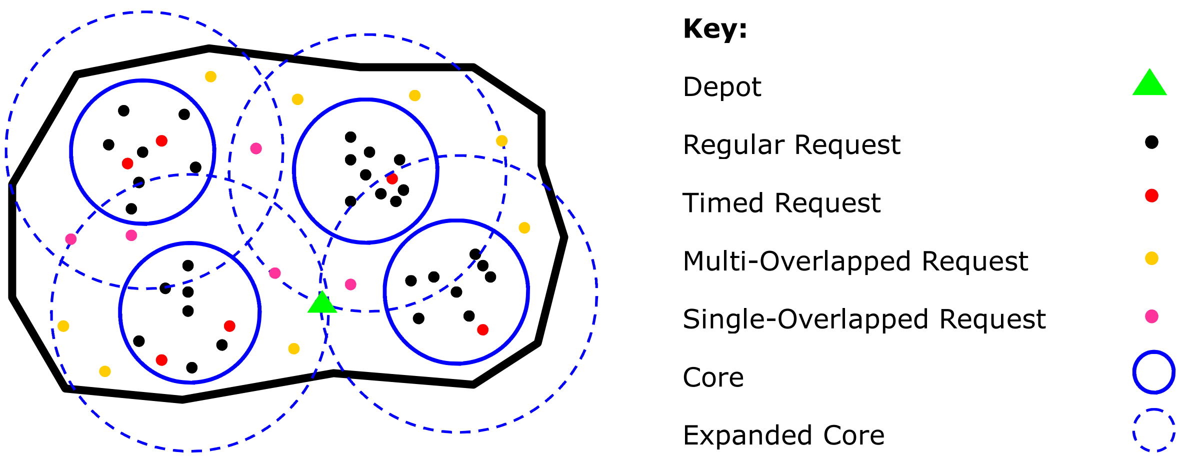


Figure 2 – Expanded Cores

Phase 3 – Genetic Algorithm

In the final phase a Genetic Algorithm (GA) is used as a parallel construction meta-heuristic to assign the unscheduled requests to the defined cores and as a solution improvement technique. GAs are used to solve hard combinatorial optimisation problems. The effectiveness of search space exploration by GA is key to its success, thus the reason for its implementation.

Step 1 – Chromosome Construction

Based on the output from Phase 2, the unscheduled request(s) overlapped by the same set of cores will form a chromosome. Each chromosome will have a population size equal to their number of requests, with a minimum length of two. Every gene in the chromosome will represent a core. The initial population in each chromosome will be randomly generated and limited to the cores defined in Phase 2.

Step 2 – Solution Construction

The combination of genes between chromosomes represents potential assignments of unscheduled requests, known as GA solutions. A GA solution combined with the core assignments will complete the construction of the solution. However, the solution may not be capacity feasible, therefore the GA solution is discarded. For the remainder that are feasible, route times are calculated for the drivers. The solution with the lowest total routing time, and if the variation between driver workload is within the defined acceptance, then this is accepted as the best solution for the population. The solution will replace the lower bound if cheaper. Once the populations of the chromosomes have been explored genetic operators are employed, crossover followed by mutation (Gendreau and Potvin, 2010). This phase is repeated until the lower bound stabilises. Figure 3 illustrates the final driver assignments.

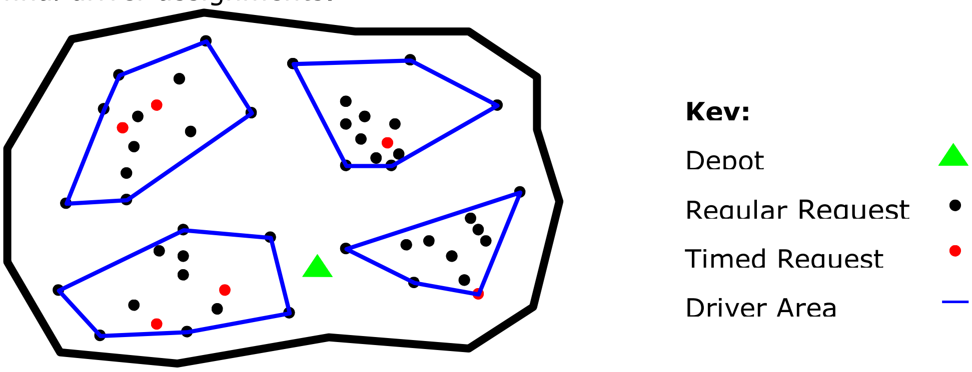


Figure 3 – Final Solution

SUMMARY

This paper provides a unique concept for constructing solutions for the NP-hard problem. It is envisaged the solutions obtained will be of a high quality, since assignment is based on the actual spatial spread of requests, unlike the current practice. The research published in this paper is intended for the parcel service industry. However, it can be applied by any scheduler involved with the daily allocation of high density requests scattered in a distribution network with many drivers, dealing with both deliveries and collections within timed constraints.

FUTURE RESEARCH

The authors' forthcoming research work will evaluate the performance of the proposed method on different size instances and for varying degrees of time restriction. Future work could also consider adopting a well known construction heuristic to complete the assignment of remaining requests to the cores. This initial population explored by GA may be of a high quality and thus converge sooner at a stabilised lower bound, when compared with the random population used in phase 3. In addition, subsequent research may entail a repairing method for a certain proportion of GA solutions that are slightly unfeasible, possibly using the well known local search techniques described previously, as it is plausible that an optimum solution may exist in the disregarded solutions.

REFERENCES

Aarts, E., & Lenstra, J.K. (2003). Local Search in combinatorial optimization, Princeton University Press.
Alonso, F., Alvarez, M.J., & Beasley, J.E. (2008). A tabu search algorithm for the periodic vehicle routing problem with multiple vehicle trips and accessibility restrictions. Journal of the Operational Research Society, Vol. 59, No. 7, p. 963-976.
Braysy, O., & Gendreau, M. (2005). Vehicle Routing Problem with Time Windows, Part 1: Route Construction and Local Search Algorithms. Transportation Science, Vol. 39, No. 1, p. 104-118.
Choudhry, O.H., & Khan, A.M. (2001). Effect of route guidance and route scheduling systems on courier pickup and delivery operations: a simulation study. Canadian Journal of Civil Engineering, Vol. 28, No. 1, p. 77-84.
Clarke, G., & Wright, J.W. (1964). Scheduling of Vehicles from a Central Depot to a Number of Delivery Points. Operations Research, Vol. 12, No. 4, p. 568-581.
Cordeau, J.F., Gendreau, M., Laporte, G., Potvin, J.Y., & Semet, F. (2002). A guide to vehicle routing heuristics. Journal of the Operational Research Society, Vol. 53, No. 5, p. 512-522.
Garcia, B.L., Potvin, J.Y., & Rousseau, J.M. (1996). The Vehicle Routing Problem with Time Windows Part 1: Tabu Search. Journal on Computing, Vol. 8, No. 2, p. 158-164.
Gendreau, M., Hertz, A., & Laporte, G. (1994). A Tabu Search Heuristic for the Vehicle Routing Problem, Vol. 40, No. 10, p. 1276-1290.
Gendreau, M., Potvin, J.Y. (2010). Handbook of Metaheuristics, 2nd ed, Springer.
Gillett, B.E., & Miller, L.R. (1974). A Heuristic Algorithm for the Vehicle-Dispatch Problem. Operations Research, Vol. 22, No. 2, p. 340-349.
Golden, B., Raghavan, S., & Wasil, E. (2008). The Vehicle Routing Problem: Latest Advances and New Challenges. Springer.
Grant, D.B. & Lambert, D.M. (2006). *Fundamentals of Logistics Management – European Edition.* McGraw-Hill Education.
Kernighan, B.W., & Lin, S. (1973). An Effective Heuristic Algorithm for the Traveling-Salesman Problem. Operations Research, Vol. 21, No. 2, p. 498-516.
Lin, S. (1965). Computer solutions of the traveling salesman problem. Bell System Technical Journal, Vol. 44, p. 2245-2269.
Liu, F-H.F., & Shen, S-Y. (1999). A route-neighborhood-based metaheuristic for vehicle routing problem with time windows. European Journal of Operational Research, Vol. 118, No. 3, p. 485-504.
Or, I. (1976). Traveling Salesman-Type Combinatorial Problems and Their Relationship to the Logistics of Regional Blood Banking. Ph.D. Dissertation, Northwestern University, Evanston, IL.
Pisinger, D., & Ropke, S. (2007). A general heuristic for vehicle routing problems. Computers & Operational Research, Vol. 34, No. 8, p. 2403-2435.
Potvin, J.Y., & Rousseau, J.M. (1993). A parallel route building algorithm for the vehicle routing and scheduling problem with time windows. European Journal of Operational Research, Vol. 66, No. 3, p. 331-340.
Potvin, J.Y., & Rousseau, J.M. (1995). An Exchange Heuristic for Routeing Problems with Time Windows. Journal of the Operational Research Society, Vol. 46, No. 12, p. 1433-1446.
Prosser, P., & Shaw, P. (1996). Study of Greedy Search with Multiple Improvement Heuristics for Vehicle Routing Problems. Department of Computer Science, Research Report 96/201, p. 1-10.
Savelsbergh, M.W.P. (1992). The vehicle routing problem with time windows: minimizing route duration. Journal on Computing, Vol. 4, No. 2, p. 146-154.
Solomon, M.M. (1987). Algorithms for the vehicle routing and scheduling problem with time window constraints. Operations Research, Vol. 35, No. 2, p.254-265.
Toth, P., & Vigo, D. (2002). The Vehicle Routing Problem. SIAM.
Wasner, M., & Zäpfel, G. (1998). Optimal Design of Transportation Networks Theoretical Aspects and a Case Study. Department of Production Management, University of Linz.
Zhong, H. (2004). Territory Planning and Vehicle Dispatching With Driver Learning. United Parcel Service, Department of Industrial and Systems Engineering, University of Southern California.

FAILURE AND RESTART OF AN AISLE: SOLUTIONS FOR A HIDDEN PROBLEM WITH SIGNIFICANT EFFECT IN HIGH BAY RACKING SYSTEMS FOR WAREHOUSING

Wildner, C
Ilmenau University of Technology – Department Industrial Engineering

ABSTRACT
Fulfilling essential functions in transport and distribution logistics, industrial warehouses are usually equipped with automatic high bay racking systems, the aisles and especially the automated storage/retrieval systems of which happen to fail temporarily in the course of operation.
The common operating strategy "uniform aisles distribution" prepares warehouse control systems for such cases of failure: the operation of the total system is usually kept up with reservations during the down-time of a single aisle. But when the necessary restoration has been carried out and the control system restarts the aisle – the efficiency of the total storage system doesn't recover to its original level but temporarily decreases even more.
This paper explains the underlying causes of this problematic effect and points out its possible consequences. Furthermore possible solutions are indicated.

REVIEW OF RELEVANT LITERATURE
Based upon a data pool covering the last 39 years about number, variety and commissioning date of high bay rackings with location in Germany, the specifications of the typical system were generated.

Their first implementation in form of an executable model showed proof of the phenomenon [Gei98] [GS01]. Experiments with up-to-date parameters and a new model in Plant Simulation, a software-tool for discrete, event-oriented simulation, reveal the correlation of down-time, range of storage units and efficiency [Wil10] and allow further examinations. The objective is the development of concepts according to common methods of design and modes of operation (e.g.[GK09]), which minimize or even totally avoid negative impacts – such as already outlined in an exemplary way [Sch10].

DESCRIPTION OF THE PROBLEM
The logical structure of warehouse control systems is designed according to the chosen operating strategies of the logistic system. The following two rules could be regarded as part of the standard set of strategies for most high-bay stores.
The "uniform aisles distribution" means, that the stock of one article is equally distributed over the aisles in order to achieve maximum accessibility and availability [GK09].
The "first-in-first-out" strategy determines the out-storing sequence of units: the storage unit, which has been stored in first, must be stored out first [GK09].

The underlying logic of both operating strategies uniform aisles distribution and first-in-first-out appears to be coherent at first sight – what might be the reason, why these strategies happen to be prescribed for storage dimensioning [GK09]. But there are situations when these two strategies interfere with negative consequences for the warehouse system as it is shown below.

Figure 1: "numbered units of one article distributed over three aisles" (cf. [Wil10]) represents schematically a high-bay store with three aisles. The aisles are numbered with 0, 1 and 2. The stock is not entirely pictured. Only the units of one single article are represented in form of small numbered squares. There are four of them stored in each aisle. The numbers of these twelve units stand for the sequence of their in-storing. The first unit, which was stored in is numbered with "1", the second with "2" and so on. Thus it is possible to understand that all units were stored in according to the strategy of uniform aisles distribution – with the result, that each aisle stores the same amount of four units.

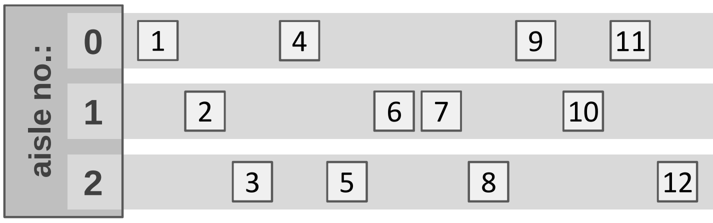


Figure 1: numbered units of one article distributed over three aisles

Assuming that aisle "0" happens to fail in this situation, figure 2: "in- and out-storing of units during downtime of an aisle" (cf. [Wil10]) shows the further development of the stock for the case that the storage devices in use are aisle-fixed. Because of the failure of the one aisle, it is impossible to store any units in or out of it. Nevertheless the operation of the warehouse system is kept up with the result, that out-storing orders are fulfilled with units from the two operating aisles.

Assuming eight units of the regarded article have to be stored out during the downtime of aisle "0", the numbered units 2, 3, 5, 6, 7, 8, 10 and 12 will be removed from stock. In an equivalent way all in-storing orders only can be carried out with the operating aisles, too. This leads to the result that eight incoming units will be stored in aisle "1" and "2" – pictured with the numbers 13 to 20 in squares with dashed lines.

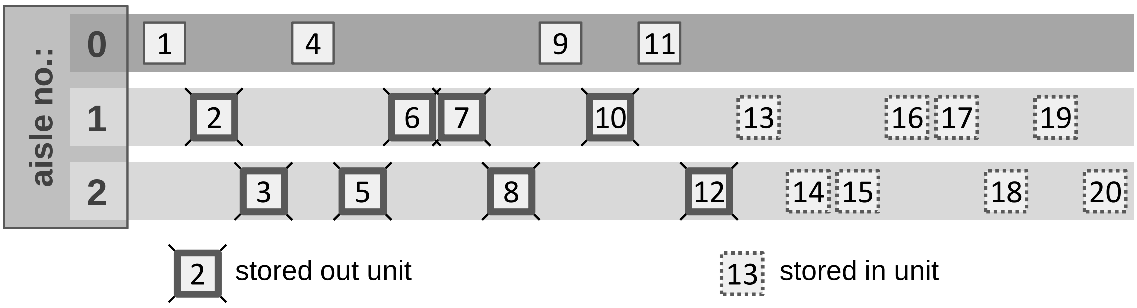


Figure 2: in- and out-storing of units during downtime of an aisle

After eight units are stored out and eight new ones are stored in, the problem which caused the failure of aisle "0" may be resolved. The downtime stops with a restart of the aisle. This situation is pictured in figure 3: "resulting out-storing sequence by failure of an aisle" (cf. [Wil10]).

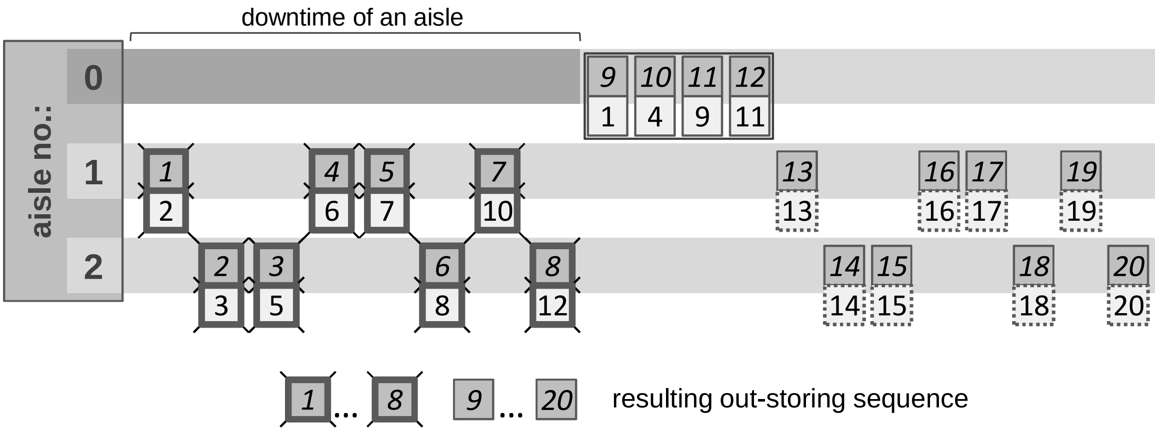


Figure 3: resulting out-storing sequence by failure of an aisle

It shows the same distribution of units as in figure 2 with some additional information: squares filled with dark grey colour are placed at the original positions of unit-symbols. They are numbered from 1 to 20 and show thus the out-storing sequence that would result in this situation, if the principle of first-in-first-out was applied. The numbers 1 to 12 are here given retrospectively to those units which were stored out during the downtime of aisle "0". The four units of the regarded article with the original numbers 1, 4, 9 and 11 spent the downtime in the failed aisle. They now form the group of the 'oldest' units – marked with an additional empty rectangle. According to first-in-first-out the units of this group have to be all stored out consecutively from their store places which are all situated in aisle "0".

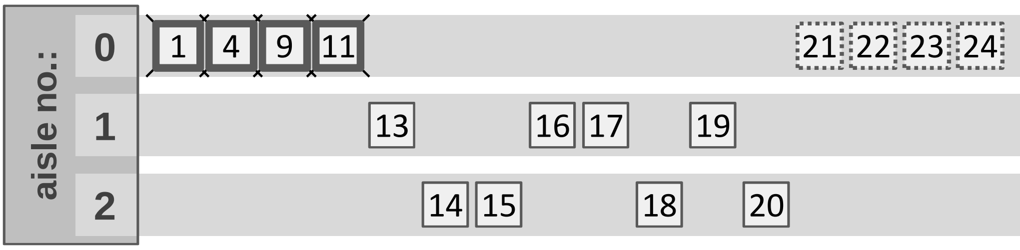


Figure 4: in-storing sequence in consequence of out-storing sequence

Assuming this group of four units are stored out one by one – each followed by one new unit of the regarded article that hast to be stored in the warehouse, the further development of this situation is illustrated in figure 4: "in-storing sequence in consequence of out-storing sequence" (cf. [Wil10]). Each removed unit reduces the stock of the corresponding aisle by one. If the strategy "uniform aisles distribution" is pursued, the reduced stock of one aisle has to be filled up with the next new entries. Figure 4 shows what happens when four new units are stored in after the group of the four 'oldest' has left the store: the sequence of storing out units of one aisle leads to a sequence of storing in new units into the very same aisle.

RESEARCH WORK

The considerations above of a limited amount of units of one single article indicate that one possible consequence of the failure of an aisle may result in a form of significantly unbalanced grade of utilisation concerning the automated storage/retrieval systems of the regarded high-bay store.

To develop and enrich the preliminary indications a simulation model was generated on the platform of Plant-Simulation which allowed examining the relevant interference of the two operating strategies in an automatic high-bay store under defined conditions and in dependence on several selected parameters.

The model represents an automatic high-bay store with three aisles. Each aisle consists of two shelf racks with 100 (length) x 20 (height) store places for storage units. All considered shelf racks are single-unit: no storage units are placed behind others – there's direct access to all storage units in the store. The range of articles and the duration of the downtime of one aisle are parameters to be defined before each experiment. The average filling degree is 80%.

The technical data of each storage/retrieval device are composed by its maximum speed and its acceleration in horizontal (index "x") and vertical (index "y") direction ($a_x = a_y = 1{,}0 m/s^2$; $v_x = 5{,}0 m/s$; $v_y = 2{,}5 m/s$), the duration of the handing over of a unit from device to a store place or vice versa ($t_z = 2{,}0 s$) and the reaction time of the device control ($t_0 = 0{,}75 s$) [GK09].

A part of the in-feed system of each aisle is a buffer place. In- and out-storing orders are continuously generated. Their contents concerning the type of article and the store place are the results of a stochastic algorithm (equally distributed).

The following operating strategies are implemented: free storage order, uniform aisles distribution, first-in-first-out, single- and double-cycle strategy. If there are both an in-storing and an out-storing order in the moment of the arrival of a storage/retrieval device at the single buffer place at the point of input for the corresponding aisle – the storage/retrieval device will carry out a double-cycle. If there's only one type of order at the relevant moment, the storage/retrieval device will carry out a single-cycle.

Further strategies, such as the fast mover concentration, and other conditions like additional buffer places would surely increase the efficiency of the storage system. Changes like these would not support the examination of the relevant effect.

RESULTS/ANALYSIS

Experiments with the described simulation model led to different results, such as the impact of varied downtimes on the maximum efficiency (see Figure 5: variations of downtime (1) (averaged graph) [Wil10]). The diagram shows the results of four different simulation experiments that differ in the duration of the downtime. Each experiment consisted of 30 simulation runs.

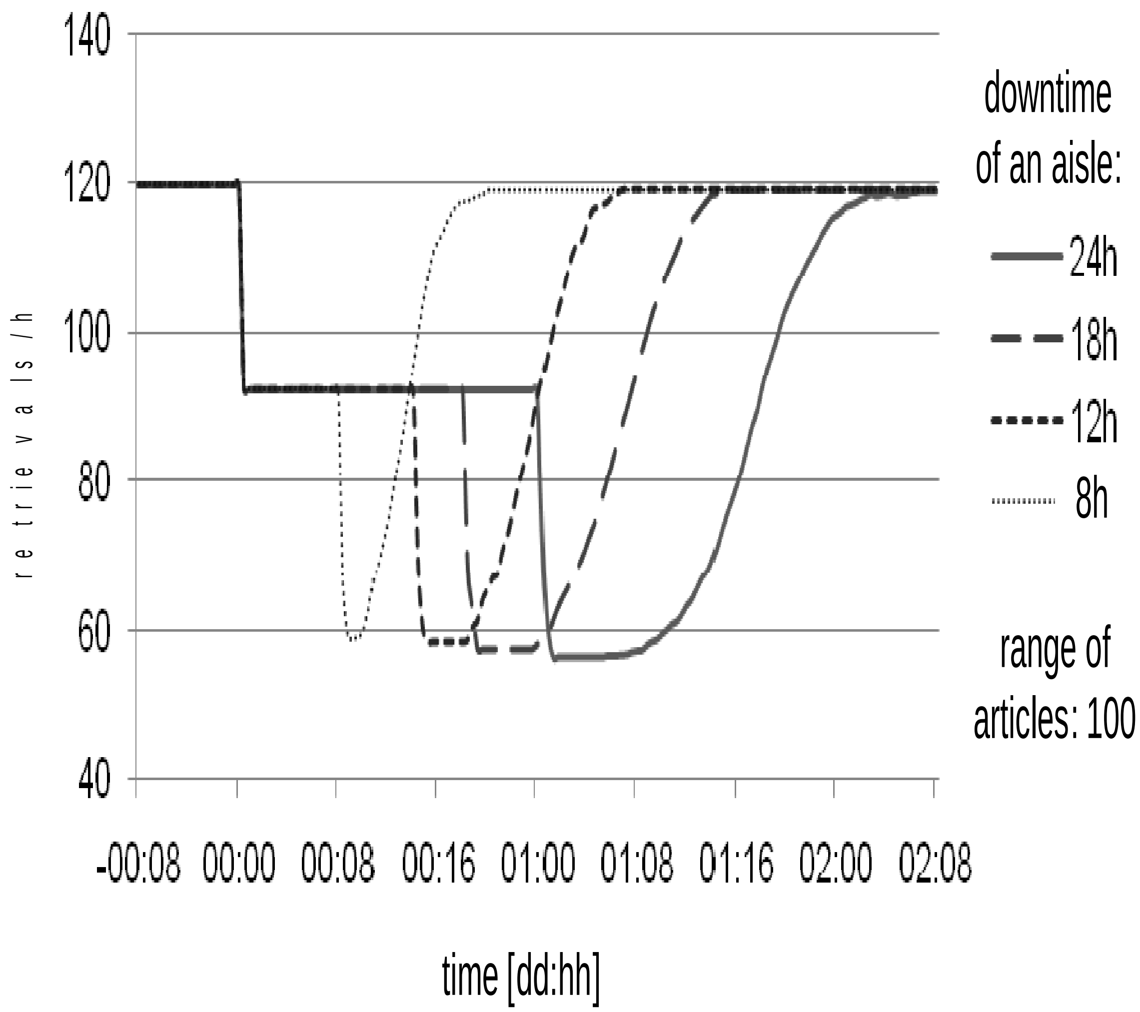


Figure 5: variations of downtime (1) (averaged graph)

Figure 5 clearly shows how the efficiency of the storage system decreases on a level of roundabout 95 retrievals/h when one aisle stops operating at 00:00. With the restart of the failed aisle, efficiency decreases again slightly below 60 retrievals/h. This level represents the maximum throughput that can be carried out by one single storage/retrieval device aisle that had failed before. This device represents a bottleneck of the whole storage system in this situation. The recovery back to the original efficiency level takes a time in dependency of the corresponding downtime.

If the downtime is reduced below 6h the decrease after the restart of the aisle is less and less extensive. The level of maximum throughput that can be carried out by one single aisle is not longer reached – see Figure 6: "variations of downtime (2) (averaged graph)" [Wil10].

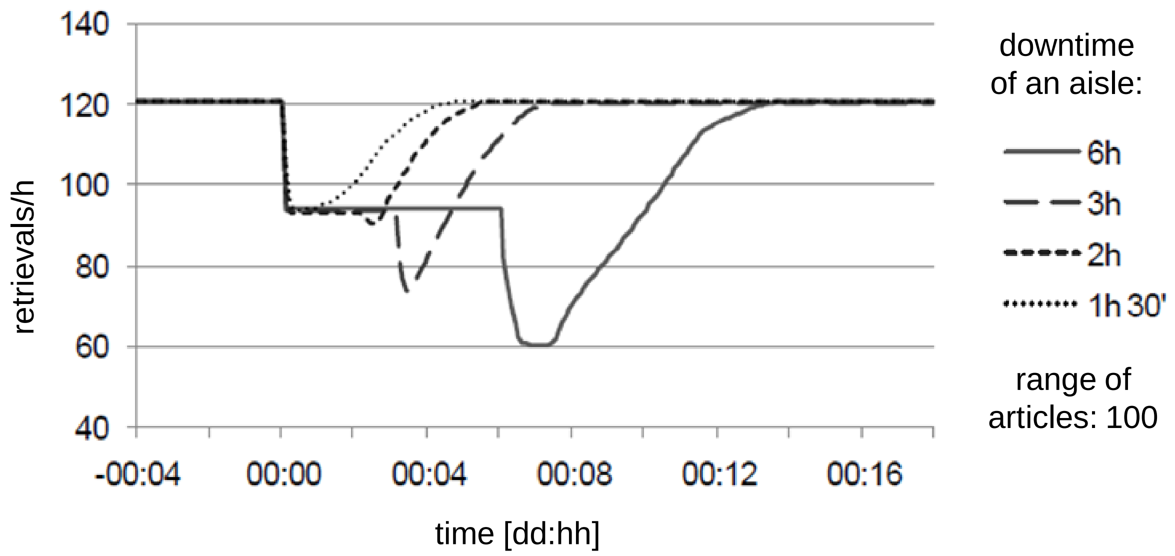


Figure 6: variations of downtime (2) (averaged graph)

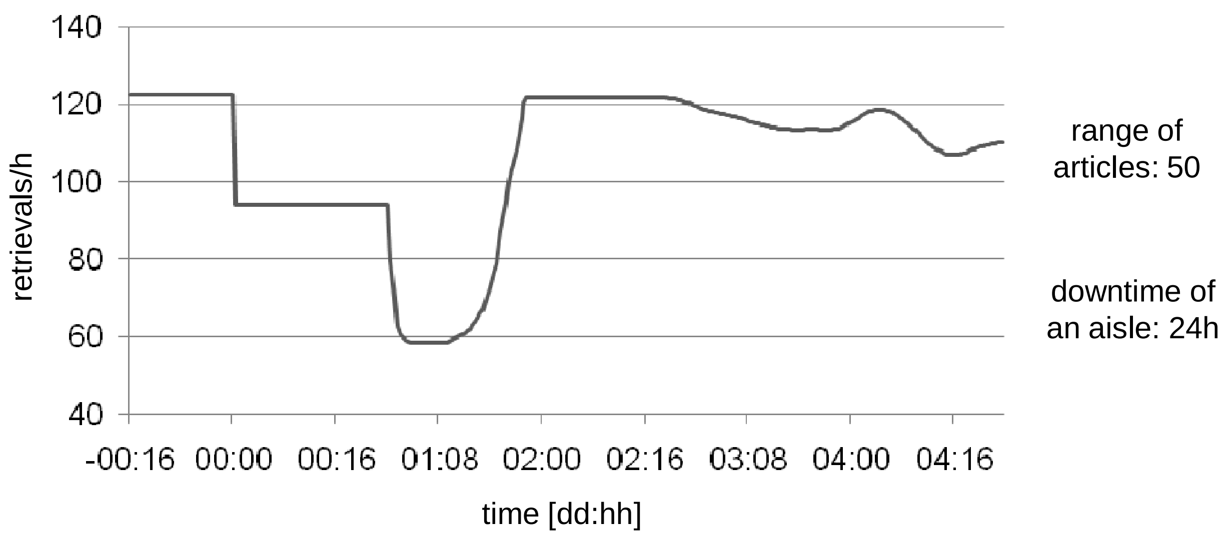


Figure 7: example of later effects (averaged graph)

Figure 7: "example of later effects (averaged graph)" (cf. [Wil10]) shows that those changes in stock distribution which cause the efficiency to decrease after the restart of the aisle may not be undone with the recovery back to the original efficiency level. The diagram of figure 7 shows that it is possible that these circumstances can cause later declines, too.

DISCUSSION

Strategies usually represent means to achieve certain objectives. Questioning the mentioned operating strategies and revealing their corresponding objectives leads to different indications for specific solutions:

The strategy "uniform aisles distribution" can be pursued for two different reasons.
The first reason might be the achievement of maximum accessibility. The term accessibility refers here on one hand to the function of storing out units of one article. In this case accessibility expresses the possibility of removing ordered units of one article from several aisles at the same time, instead of removing them all consecutively from only one aisle. On the other hand accessibility can also refer to the process of how units of one batch are stored in. The necessary time of this process can be reduced by distributing them over several aisles instead of putting them altogether in one single aisle.
These explanations show that the term of maximum accessibility in this context is obviously used as one possibility to increase throughput or efficiency. There are surely other possibilities such as other operating strategies to achieve this objective, too.

The second reason for pursuing the strategy of uniform aisles distribution is expressed by the term of availability. Stored units should be available at any time and under any condition. The failure of an aisle could make it impossible to remove the ordered amount of units of an article from the store if all of these units were stored in right the failed aisle. If all units of an article were distributed over several aisles of the store instead, the failure of one aisle would be of no further consequence as long as the ordered amount of units can be removed from other aisles.
The concept of the interruption reserve [GK09] may appear as a restriction to the idea of maximum availability: the interruption reserve serves as a reserve stock that is preserved for cases of accidentally interrupted supply caused by failure, breakdown or damage. In this context the distribution of more than the defined reserve stock is unnecessary in terms of availability.

The strategy first-in-first-out was originally applied to save those goods with limited durability or expirations dates. It efficiently helps to prevent single units from extensive times of storage. First-In-First-Out was thus implemented more and more for all other kinds of inventory, too [Gra93].
Regarding the inventory risk rate could be taken as an alternative in generating an out-storing sequence. The inventory risk rate takes into account the storekeeping risks, such as shrinkage, ageing, deterioration, obsolescence and loss [GK09]. This rate in connection with the turnover rate of one article should make it possible to define a priority algorithm for out-storing with less of the described negative side effect of first-in-first-out.

CONCLUSIONS

The described phenomenon can be taken as an example for the limitations of the existing concept of availability in technical logistics: the focus on failures without taking into account their further consequences might miss significant effects.
Different strategies in use might interfere with hardly predictable negative consequences within or between other logistic systems, too. The approach of managing the risk of a supply chain in combination with means of simulation should be able to deal also with similar problems in future.

The given explanations should make designers and operators aware of the described problem. Questioning the relevant operating strategies made it possible to indicate possible solutions which should result in the development of efficient modifications for warehouse control systems to avoid the significant declines in efficiency in consequence of failures of single automated storage/retrieval systems. The presented information contributes to the design of efficient warehouses, to the quality of the management of supply risks and to the service level of transport and distribution networks in general.

REFERENCES

[Gei98] Geinitz, Jens: Unerkannte Abhängigkeiten mindern die Leistungsfähigkeit automatisierter Lager. In: Marktbild Lager, Bd.18 (1998), p. 16-18

[Gra93] Grafe, Wolfram; Jünemann: Gestaltung und Betrieb von Lagersystemen mit hohen Umschlagleistungen. In: Jünemann, Reinhardt: Logistik für die Praxis. Dortmund: Praxiswissen (1994)

[GK09] Gudehus, Timm; Kotzab, Herbert: Comprehensive Logistics, Berlin, Heidelberg: Springer (2009)

[GS01] Geinitz, Jens; Scheid, Wolf-Michael: New Demands on automated Logistics Systems to be met by new Strategies. In: Proceedings of the 6th. Pawar, K.S.; Muffatto, M. (eds.): Logistics and the Digital Economy. Proceedings of the 6th International Symposium on Logistics, Salzburg, Austria (8th-10th July, 2001)

[Sch10] Scheid, Wolf-Michael: Havarie bei Anlagen der Intralogistik. In: Jahrbuch Logistik 2010, Bd.24 (2010), p. 30-33

[Wil10] Wildner, Christian: Anlaufstrategien für Hochregallager bei Wiederinbetriebnahme eines ausgefallenen Regalbediengeräts. In: Wissenschaftliche Gesellschaft für Technische Logistik: Tagungsband 6. Fachkolloquium der Wissenschaftlichen Gesellschaft für Technische Logistik (WGTL), Garbsen: PZH Produktionstechnisches Zentrum (2010), p. 163-174

TRANSPORT OF DANGEROUS GOODS IN TURKEY: AN ANALYSIS IN THE CONTEXT OF EU INTEGRATION

Dilay Çelebi, Matthias Klumpp***
*Department of Management Engineering Istanbul Technical University, Turkey
**Institute for Logistics and Service Management (ild), FOM University of Applied Sciences Essen, Germany

ABSTRACT
This paper provides a general record of information on the sector characteristics of road transportation of dangerous goods in Turkey. It entails a multiple case study analysis of dangerous goods transportation sector through an empirical field research using primary data based on semi-structured interviews with key people from the organizations responsible for the transportation of dangerous goods, as well as a secondary data analysis, focusing on previous academic publications and research findings published by international or governmental organizations and public/private agencies.

Purpose:
The purpose of this paper is to support practices to improve the efficiency and security of dangerous goods transports by identifying issues and problems concerning the application and control of rules and regulations in line with the road transport legislation of the European Union, in terms of road safety and social, fiscal, and technical rules. Relevantly, this study aims to develop a general overview regarding the dangerous goods transportation sector in Turkey with relevance to integration of ADR. It includes identification of the types and amounts of dangerous material transported through Turkey and Europe, as well as the routes used for transporting these materials with particular emphasis put on networks between Turkey and Germany.

INTRODUCTION
Improving the efficiency and security for transportation of dangerous goods (DG) is important due to several reasons. Perhaps most important one is safety, such that a transport containing dangerous goods can have severe effects on the environment in case of an accident and often incurs a higher cost for the society than non dangerous goods accidents (Ellis, 2002). Another reason is the complexity of the operations. Transportation of dangerous goods is more complicated than non dangerous goods due to several factors such as the large number of regulated hazardous materials, regulations that vary by transportation mode, region and country, and different hazard criteria, including toxicity, flammability, corrosiveness, and reactivity (Fuller, 2009).

Major goal of the regulations on transportation of dangerous goods is to provide a safe and secure transportation of dangerous materials by eliminating or reducing the number of incidents that could lead to a release or misuse. For road transport in Europe, the legal framework defined in the "The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)" is relevant. ADR has been revised and put into force in 2009 which governs the conditions for the international transport of dangerous goods within the 33 European ADR countries. It has been drawn up to improve safety in international road transport and to replace the variety of national and local regulations in Europe, which are applicable to the international transport of dangerous goods, by a set of jointly-agreed conditions under which the international transport of dangerous goods is authorized within the borders of all ADR countries. These conditions have been drawn up to take into account all safety parameters (such as temperature, climate, topography, population density) involved in the national regulations to be replaced. It includes rigid safety standards for vehicles, safety training, and driver training for hazardous materials transporters.

In Germany as the largest transportation and freight market in Europe 8% of all

transported goods are dangerous goods, amounting to a total of 353 million tons in 2008 (Federal Statistical Office Germany). About two thirds of these total transport volume regarding dangerous goods in Germany are consisting out of oil and gas products, varying across the different transport modes (up to 80% in sea and inland shipping).
In a historical data view the total volume of dangerous goods shipments has increased by 3,81% from 2005 (340 million tons), an average of 1,27% per year. The following table specifies the German modal split in dangerous goods in 2005 and 2008, showing that a problematic development is under way shifting the transport volume from safer transport modes (ship and rail) towards the truck transport segment. This could lead to increasing risks of accidents and should lead to intensified regulations and political concepts to cope with this development.

	Truck	Ship (Sea)	Rail	Inland Waterway
Transport Volume Germany 2008	171,000,000 tons	73,000,000 tons	59,000,000 tons	50,000,000 tons
Change	+ 11,000,000 tons	- 1,000,000	+ 3,000,000	+/- 0
Transport Volume Germany 2005	160,000,000 tons	74,000,000 tons	56,000,000 tons	50,000,000 tons

Source: Federal Statistical Office Germany 2010, p. 846; Federal Statistical Office Germany 2007, p. 370

Turkey has to comply and update its legislation on the transport of dangerous goods and to respectfully the EU rules which rely on the ADR and RID Conventions (on international carriage of dangerous goods by road and by rail). Regulation Concerning the transport of Dangerous Goods by Road has been declared in 2007, based on Law on Approval to Join the European Agreement on International Transportation of Dangerous Goods. The Turkish Regulation is structured to refer to the applicable paragraph numbers of the ADR. The original intent was to put this regulation in force by 2009; however, this date is postponed three times up to 2012 due to insufficient preparations for effective implementation and enforcement of social, safety, technical and environmental standards required by the agreement.

The purpose of this paper is to support practices to improve the efficiency and security of dangerous goods transports by identifying issues and problems concerning the application and control of rules and regulations in line with the road transport legislation of the European Union, in terms of road safety and social, fiscal, and technical rules. Relevantly, this study aims to develop a general overview regarding the dangerous goods transportation sector in Turkey with relevance to integration of ADR. It includes identification of the types and amounts of dangerous material transported through Turkey and Europe, as well as the routes used for transporting these materials with particular emphasis put on networks between Turkey and Germany.

To authors' knowledge, this study is a pioneer in literature by providing a complete record of information on the general sector characteristics of road transportation of dangerous goods in Turkey. It would be the basis of further research regarding detailed sector analysis, management concepts (e.g. training concepts) to overcome important hurdles and limitations existing today in this specific transport sector. This would complement existing research in risk assessment and risk management regarding dangerous goods transportation (Fabiano et. al. (2003), Purdy, G. (1993)).

METHOD
This study entails a multiple case study analysis of dangerous goods transportation sector through an empirical field research using primary data based on semi-structured interviews with key people from the organizations responsible for the transportation of dangerous goods, as well as a secondary data analysis, focusing on previous academic

publications and research findings published by international or governmental organizations and public/private agencies.

The study conducted in this paper is limited to transport of dangerous materials by road which is in line with the scope of ADR. First, a literature study of relevant articles, law texts, reports, dangerous goods transport documents, statistics, and previous qualitative and quantitative research is conducted to identify the important factors affecting management of dangerous goods transportation. The literature study is followed by an empirical study consisting of interviews with companies which are transporting dangerous goods. Interview templates for the different categories of employment were created to be able to identify key issues concerning safety, security and efficiency.

Data was collected in personal interviews in March 2011 from seven medium-sized or large DG transporter firms and organizations. The initial selection of cases was made by type of goods (liquid and dry bulk, unitized and general cargo) and the most important DG classes. The general purpose of the interviews is to depict a true picture of dangerous goods transport flow to and from Turkey within Europe, and to identify problems at the transport interfaces. Another purpose is to investigate how well ADR rules and regulations works in practice and to find problems related to the application situation today.

Questions used to guide the interviews are prepared to cover the important factors collected from the literature review. These include volume, sector size, organizational structure, company size, handling, transportation volumes, expectations, encountered problems, regulatory standards, operations management systems, certification and education.

Questionnaire is prepared also in line with the ADR agreement to cover Section 5 (Consignment procedures), Section 7 (Provisions concerning the conditions of carriage, handling, loading, and unloading), Section 8 (Requirements for vehicle crew, equipment, operation and documentation) and Chapter 9 (Requirements concerning the construction and approval of the vehicles).

The interviews were performed mainly at the organizations' offices or over the phone with Managers and leaders of organizations including important actors in the dangerous goods supply chain such as haulers, forwarders, consigners, consignees to obtain answers to following questions:

1. What is the current state of dangerous goods transportation sector in Turkey?
2. What are the existing rules and regulations concerning dangerous goods transports on road?
3. What are the application and control situation of DG regulations in Turkey?
4. What are the problems concerning application and control of rules and regulations in Turkey?
5. What are the current problems related to operations of dangerous goods transportation?
6. What implementation barriers exist to reach the desired flow?

ANALYSIS

This section gives an analysis of the responses and reactions from the questionnaires and the interviews. Suggestions for changes or improvements to the regulations (RID/ADR/ADN) were made by a number of respondents and sometimes more than one suggested the same or similar change. However, it should be made clear that there was never unanimous support for any changes that are described below.

SECTOR OVERVIEW

All interviewed companies are engaged in international transportation except C6. Company 1 provides land, air, sea, rail, intermodal transportation as well as warehousing, vehicle logistics, bulk cargo transportation, home-office logistics, customs clearance, insurance, and logistics consulting services. Their main office is located in Turkey Turkey and but they have various offices around Europe. C1 holds ISO 9001:2008 quality management system certificates, ISO 10002:2004: customer satisfaction and customer complaints management system certificates, and ISO14001 environmental management system certificate. Company 2 (C2) is an international company which uses road, air and maritime modes to support logistics of materials in factory, power plant or port construction projects, as well as provides gas distribution service. Company 3 (C3) provides international road transport solutions and services that include import export shipments, partial-complete journeys, textile and garment transportation, automotive sub-industry transportation, order management, door to door delivery, general warehouse, and daily grouping services. Company 4 (C4) operates in international transportation and logistics services for automobile supplier services, oil and petrol sector. Company 5 (C5) is a provider of road, air, sea, and rail transportation, customs clearance, and insurance services. Finally, Company 6 (C6) provides in sea and land transportation and is engaged in the production and filling operations.

Two of the companies own a fleet size of 1000-1500 trucks, while remaining four companies has a fleet size of 0 - 500. Length of a return domestic trip varies between 450-1200 km and, while international trips take 3000-6500 km on the average. The number of trucks varies. The smallest company owns 13 while largest has 600 available for transportation of dangerous goods. Similarly respondent companies vary in means of organizational size with 90 employees for the smallest firm which goes up to 1100 for the largest company.

TYPES AND ROUTES

Dangerous goods on road are transported both in tanker trucks and mixed cargo trucks. The largest volumes transported are, however, petroleum products, which are transported in tanker trucks all over Turkey. In general inflammable liquids, Class 3 according to ADR-S is a common type of goods. Since many industries are in the vicinity of Istanbul many dangerous goods transports are conducted there. The class that is transported most frequently on Turkish roads is class 3, Flammable liquids e.g. petrol & diesel and it is probably the most common class for the rest of Europe as well. On the average 22 million tones of dangerous goods are transported annually through Turkey where class 3 represents 90% of the DG transported on Turkish roads (Petder, 2010).

Most commonly used transportation route is France-Germany-Austria-Hungary-Romania-Bulgaria while the alternative routes go through Italy-Greece or Slovenia-Bulgaria. These routes are determined due to risk structures and transportation regulations as well as requirements of particular types of dangerous goods. Companies prefer trouble and risk free routes while considering additional requirements such as tunnel crossing limitations for particular materials. Other factors to determine the routes are client's demands and document requirements.

RISK AND SAFETY

Transportation of dangerous goods has shown to be critical from a damage perspective. Although the industry has an excellent safety record, accidents do happen, and the consequences can be significant, due to the nature of the cargo. What causes accidents at transports interfaces probably differs significantly from what causes accidents that occur when en-route. Often a release of dangerous goods at a transport interface is caused by incidents such as errors in loading and unloading bulk cargoes, or dropping and damaging packages. All interviewed companies declared compliance with ADR regulations. Out of six, only C1 has declared recorded cases of accidents in the last 15 years. First incident is recorded in 2005 in Germany where a company owned ADR loaded truck burned and driver was wounded. Second is reported in 2009, an aerosol loaded semi-trailer burned in the parking area.

Most interviewed companies agree that Class 3 materials (Flammable Liquids) are the most risky DG class that incurs the highest risks during transportation and handling. C1 identifies materials grouped under Class 6 (Toxic substances) as the highest risk holders. Transportation is identified as the most risky operation among the four main logistics operations: transportation, loading, un-loading, and storage due to damages caused by slipping-tipping incidents that may occur during transportation of packaged materials. C2 gives the highest priority to transportation, followed by unloading and loading operations. C6 declares risk indifference in operations of transporting liquid natural gas with tankers.

All companies agree that the scope and the number of rules and regulations governing each single mode of transport of dangerous goods are sufficient. According to many interviewees, in general, current rules and regulations have reached a level that is good enough according to what the society expects. In order to achieve expected efficiency and safety level, rules and regulations must work together with control and the focus now should be to control that the regulations are followed.

Manager of C1 considers the packaging regulations and standards as the main ... to control risks associated with transportation. The labels on the outer packaging of the dangerous goods indicate the hazards of the dangerous goods present which acts as the warnings to all those involved in the transportation. If a substance has several hazards features, the primary one decides the classification. However, the package unit must be labeled with both the primary classification and the secondary ones, in a decreasing order (ADR). If the packaging is performed under requirements and regularly controlled, risk factors might be eliminated substantially.

According to C2, DG transportation sector in Turkey includes high safety risks created by small sized companies operating out control of ADR standards. Vehicles used in transportation by such companies are mostly old, unmaintained, and do not hold an ADR certificate. In order to reduce the risks, companies involved not only in international transport of dangerous goods but domestic traffic should be enforced to the regulations set by ADR on classification of dangerous goods, their marking and labeling and packaging standards, also some much more detailed provisions such as the types of packaging, the consignment procedures, transport equipment, transport operations, training of drivers, supervision, emergency procedures, loading and unloading, placards of vehicles.

ADR enforces that truck drivers and related personnel should have enough knowledge about rules and regulations. However interviewees express problems related to management of the personnel and pre-transportation documentation. Lack of knowledge or education on rules and regulations is the typical problem especially for drivers. Often, small sized companies that don't transport DG frequently are lacking knowledge about the regulations. For example, C1 states that even though the DG drivers hold ADR certification, problems occur due to lack of knowledge in transportation and documentation processes. Another problem encountered with international transportation is related to the documentation requirements. C3 reports large number of truck delays and border crossing problems associated with missing or insufficient documents and serious shortfalls in documentation.

More and better structured random controls need to be regulated for administrative personnel and certified truck drivers. Drivers' license could be certified every fifth year but drivers should update their knowledge frequently according to the regulatory changes. For example, one bad situation is that the ADR instructor for drivers' license is too weak, e.g. it is possible to buy the certificate. Based on such, operationally, more resources are needed for controls. And strategically, there is a need for clear ambitions from the Government with specialized money or resources to build the business to a desired level.

PROBLEMS AND EXPECTATIONS

One of the common problems that has been specified by most of the interviewed companies is related to driver certification. The number of training and testing companies is limited and the capacities are not sufficient. In the best case it generally takes around 5-6 months to collect a certificate for a driver; 3-4 months for examination appointment and 1-1.5 months for receiving the documents. Hence, companies prefer to take risks by employing uncertified drivers rather than waiting for the approval. Low control standards allow the companies to behave contrary to ADR regulations. Most companies agree on the enforcement of immediate and strict control of conformance with ADR standards.

Another common problem appears as the lack of implementation preparations for ADR regulations. Companies expect at least 20 years of an implementation period. For example there exist almost 20.000 tankers that operate in the sector but not confirmed under ADR regulation. There is no common sense about the denouement of these vehicles and how the gap can be fulfilled. Also, definition of term "safety advisor" is found ambiguous, and uncertainties exist in auditing and inspection processes due to misunderstandings of the document contents.

One strong threat for the sector has been identified as an expected decrease in operational quality levels due to inadequate control and audit activities and increased competition. When conformance to regulations is not fully controlled, with the pressure of increased competition, companies might seek unsafe solutions to cut down operational and equipment costs.

Most companies emphasize on the importance of shortening the documentation period here long periods might result with cancellation of the transportation for small sized companies. Another recommendation comes for the training of regular drivers about the dangerous goods transportation such that they can behave more consciously in the traffic.

TRAINING AND TECHNOLOGY

According to ADR regulations a driver needs to attend different training sessions depending on which dangerous goods he or she is transporting, before starting out. These have to be followed up by refresher courses within five years of the basic training in order to not lose the ADR certification. The available courses are: Basic ADR training for general cargo, special course for transportation of substances and items belonging to class 1, special course for transportation of substances and items belonging to class 7, special course for transports including tanks. Drivers only handling limited quantity only need a course involving chapter 1.3 in ADR-S.

Four of the interviewed companies express that they comply with the ADR regulations, obtain training from internationally certified trainers and renew the process under legal conditions. Other two companies provide self training courses within the organization.

Most companies do not have a separate operational control system to manage the hazardous material transport processes and technologies. They use standard vehicle tracking systems and manually collected data to manage and control the operations. All companies hold a vehicle tracking system to keep track of all incidents of sudden acceleration, sudden braking, swing, speed violations, etc. C4 is the most technologically equipped company among others. They use specified temperature control systems to measure the temperature changes of the materials. They also use an online billing system. Their warehouses are equipped with barcode and RFID automation systems and internet based optimization applications. These systems provide online information transfer between vehicles and the management center; hence improve performance and capacity utilization by performing vehicle/load optimization.

CONCLUSION

This study demonstrates experts' ideas of 6 main dangerous transportation companies and a professional organization about issues and problems concerning the application and control of rules and regulations in line with the road transport legislation of the European Union, in terms of road safety and social, fiscal, and technical rules. Presented multi-case study analysis develops a general overview regarding the dangerous goods transportation sector in Turkey with relevance to integration of ADR. This study would be the basis of further research regarding detailed sector analysis, management concepts (e.g. training concepts) to overcome important hurdles and limitations existing today in this specific transport sector.

Findings of this research provide planners with a better understanding of dangerous materials transportation patterns and can be used to support further studies on planning and estimating risks. Results lead to a general recommendation of suitable components to be included in a more detailed future analysis. Since several of these services were developed from adjusted results of earlier research studies where the authorities' needs were in focus this system should satisfy both public and private actors' needs. It should, however, be noted that it should be possible for the companies to adjust the specifications of the system because both size of company and type of goods transported influence the procedures followed.

REFERENCES

Fabiano, B., Currò, F., Palazzi, E., Pastorino, R. (2003): A framework for risk assessment and decision-making strategies in dangerous good transportation, in: Journal of Hazardous Materials, 93 (1), 1-15.

Federal Statistical Office Germany (2010): Gefahrguttransporte 2008, Wirtschaft und Statistik 09/2010, Wiesbaden, p. 846-853.

Federal Statistical Office Germany (2007): Gefahrguttransporte 2005, Wirtschaft und Statistik 04/2007, Wiesbaden, p. 370-377.

Fuller, B.A., 2009. Managing transportation safety and security risks, Chemical Engineering Progress; Oct 2009; 105, 10; ABI/INFORM Trade & Industry, pg. 25.

Ellis, J. (2002) Risks in dangerous goods transport an analysis of risk in road rail and marine transport, Gothenburg, Sweden, Department of Transportation and Logistics Chalmers University of Technology.

Erkut E., Tjandra, S.A., Verter, V. 2005. Hazardous Meterials Transportation''. C. Banhart ve G. Laporte (Ed.), Operations Research Handbook on Transportation Ch. 11, Canada, 161-176.

Purdy, G. (1993): Risk analysis of the transportation of dangerous goods by road and rail, in: Journal of Hazardous Materials, 33 (2), 229-259.

PETDER (Petrol Sanayicileri Derneği) 2010 Sector Report, 2010.
United Nations (2010): ADR 2011, New York.

THE FUTURE OF ROAD TRANSPORTATION – A BACKCASTING STUDY

Martin Zimmermann[1], Dr. Heiko A. von der Gracht, Dr. Inga-Lena Darkow
Center for Futures Studies (CEFU), Supply Chain Management Institute (SMI)
European Business School (EBS), Wiesbaden, Germany

Research Paper

INTRODUCTION

Mobility nowadays represents one of the major challenges concerning sustainability, since a trade-off between economic necessity on the one hand and mainly ecologic damage on the other hand can be found (Köhler et al., 2009): Economic necessity means that mobility and therefore using vehicles implies being competitive from a commercial perspective (European Commission, 2001). Furthermore, cars serve not only as a means of transportation, but also as sources of personal identity and social status (Urry, 2004). Additionally, the automotive industry represents the single largest manufacturing sector in the world (Nieuwenhuis, Wells, & Vergragt, 2004) and is also one of the main generators of wealth and employment in the European Union. On the other hand, road transport is one of the largest contributors to greenhouse gas emissions (GHGs) and transport is the sector with the highest growth rate of GHGs (Hensher & Button, 2003).

In order to better manage the trade-off between economic necessity and ecologic damage of personal mobility, the automotive industry faces a radical technological change and systemic innovations towards sustainable mobility that shake the entire industry (Zapata & Nieuwenhuis, 2010). Not only the German automotive industry landscape seeks to establish a more sustainable mobility, but also other nations such as Japan, China, or the US are trying to dominate the future growth market of e-mobility. An example for such changes is the plan of the German government to establish up to 1 million electric vehicles on the streets until 2020 and over 5 million vehicles until 2030 (Federal Ministry of Transport, Building and Urban Development, 2009). This can be seen as the start of a systemic transition towards electric mobility in Germany.

Within the field of futures studies an approach for achieving transitions towards a sustainable future is backcasting (Dreborg, 1996). Dreborg (1996) defines a set of application criteria for the backcasting approach. Thus, backcasting is particularly useful when complex and persistent problems are in focus, dominant trends are part of the problem, external factors are present, the need for major change exists, and the time frame and thematic focus allow for radical changes.

The purpose of this paper is to show how the backcasting approach can be applied for the road transportation and mobility sector. We exemplify a whole backcasting process along with a recent scenario study on the future of the automotive industry that analysed how future automotive power train technologies should evolve and what the necessary steps are to realize such a desirable scenario.

OVERVIEW OF BACKCASTING

In the past, the backcasting approach was used for different research purposes. According to Quist and Vergragt (2006), three different phases of backcasting studies can be identified: Backcasting in energy studies, backcasting for sustainability, and Participatory backcasting. Drawing from the different backcasting approaches and experiences, we developed an innovative participatory backcasting approach. Concerning its different steps, it can be best compared with the approach used by Svenfelt et al. (2011), enhancing the methodology concerning the development of future images and influential factors as well as the discussion of realising future images. In the optimal case, all relevant interest groups are included in order to develop the desirable scenario and examine pathways to realise this scenario. The backcasting approach used at hand consists of four subsequent steps:

[1] To correspond to

1. Strategic problem orientation
2. Development of future images and influencing factors
3. Development of measures
4. Continuation

In the following paragraphs, we will elaborate on each step in detail.

1. Strategic problem orientation

In the first step of our backcasting approach, we identified the fundamental research topics to be addressed. For this purpose, several stakeholder workshops were held. In addition, the findings of the workshop were enriched by comprehensive desk research activities. For the underlying study, we focused on the German government's plans to reduce CO_2 emissions by supporting new mobility technologies: The German federal government announced to reduce carbon dioxide emissions until 2020 by 40%, compared to 1990 (Federal Ministry of Economics and Technology, 2007). A key pillar is strengthening e-mobility: The goal is to account for one million electric vehicles in usage until 2020 and over five million vehicles until 2030 (Federal Ministry of Transport, Building and Urban Development, 2009). The automotive industry faces a radical technological change and systemic innovations that shake the entire industry (Zapata & Nieuwenhuis, 2010). Not only the German automotive industry landscape seeks to establish e-mobility, but also other nations such as Japan, China, or the US are trying to dominate the future growth market of e-mobility. Therefore, it is of utmost importance for the German automotive industry to be prepared for the challenges ahead.

For the development of the future projections, we followed an iterative process based on a PEST-analysis (**p**olitical, **e**conomical, **s**ocial and **t**echnological factors): Firstly, relevant and challenging drivers regarding the future of sustainable mobility where emblazed by conducting intensive desk and data base research. After a wide-ranging research, we finally concentrated on in-depth analysis of a sample of academic studies and governmental-related reports. Secondly, we invited 11 business and six academic experts to take part in a future workshop where the already identified drivers were presented while further driving factors were elaborated on. Overall, we identified driving factors which built the fundament of the projection development process. The experts were asked to merge and aggregate the drivers. Consequently, we formulated 20 projections in short, descriptive and provoking propositions. In a final step, we tested the projections for ambiguity, consistence and face validity and revised them according to our research purpose.

2. Development of future images and influencing factors

For the development of scenarios for sustainable logistics and mobility, we conducted a real-time-Delphi study with focus on 2030.[2] According to Armstrong (2001), Delphi is a "method for obtaining independent forecasts from an expert panel over two or more rounds with summaries of the anonymous forecasts (and perhaps reasons for them) provided after each round" (p. 776).

We classify our backcasting approach as participatory, since Delphi can be defined as "a group process which utilizes written responses as opposed to bringing individuals together ... it means for aggregating the judgments of a number of individuals in order to improve the quality of decision making" (Delbecq, Van de Ven, & Gustafson, 1986, p. 83). This means that a Delphi process helps to execute a more structured group discussion than it would be possible with focus groups – the method that is usually used in backcasting exercises. The usage of our real-time Delphi tool resulted in a participation of 140 experts, equalling a response rate of 31% (of 441 invitations). The expert panel consists of a diverse sample of experts from 15 different groups including OEMs, supplier, political decision maker, Non-governmental experts, and academics.

[2] For a detailed description of the real-time methodology see von der Gracht et al. (2011) and Gnatzy et al. (2011).

Based on the quantitative and qualitative expert data, we were able to develop a desirable scenario in a valid and reliable way. The creation of scenarios based on Delphi data has been executed before, e.g. by von der Gracht and Darkow (2010). For this purpose, we took a closer look at the experts' ratings of the most desirable projections.

The desirable scenario is characterized by the following aspects:

> In 2030…
>
> …electric drives (especially battery-electric vehicles, range extender and plug-in hybrids) dominate the number of new registrations in Germany. Conventional power trains cannot keep up with electrical drives with regard to essential performance indicators, environmental friendliness, and total cost of ownership. The success of electric vehicles was supported by three key developments: (1) the increased willingness of customers to pay more for these drive systems, (2) the fact that a large part of energy obtained for new drive concepts originates from renewable sources, as well as (3) the comprehensive provision of efficient and cheap charging facilities for electric drives - even in rural areas.
>
> In the segments of medium and light commercial vehicles partially or fully electric drives are standard, especially since in many urban areas, in recent years only vehicles were allowed to pass that are not causing any kind of local emissions. The market for new drive concepts is dominated by manufacturers from Europe and Asia alike: European manufacturers are positioned in the area of complex new drive systems, while Asian manufacturers dominate the market segment of the less sophisticated and affordable new drive concepts.
>
> In this case the raw material supply does not constitute a bottleneck in the dissemination of new drive concepts: First, there is high global political stability. Second, not only different raw materials are used as substitutes, the industry has also found ways to recycle all materials and fluids in the sense of a closed loop. The customers mainly use an optimally coordinated network of multi-modal mobility services (public transport, car sharing, own car, etc.).

Apart from the plausible and consistent scenario story, the participants provided more than 2,000 qualitative arguments. The arguments were coded to identify patterns in the participants' argumentation. The main factors that were identified by coding the arguments of the Delphi panel participants are: Energy mix for vehicle operation, Infrastructural conditions, Customer preferences, Raw material supply, Government intervention, Technological maturity, Changing market structure, Comodal mobility, and Germany's competitiveness.

3. Development of measures

In order to analyse the path to the desirable scenario for 2030, 43 expert interviews were conducted.
The three main goals of the interviews were the following:

1. Identification of measures to implement the desirable scenario
2. Identification of actors that need to become active in order to make the changes happen
3. Determination of the timeliness of the various measures

A total of 43 interviews were conducted with experts proceeding from 15 different interest groups similar to the Delphi survey. We aligned the interview sample's distribution in order to achieve equilibrium among stakeholder representation.

For the semi-structured interviews we specifically developed a graphical interview guide that was tailored to the needs of a backcasting exercise. Every interview started with a briefing (Delphi results, desirable scenario etc.). If agreed upon, interviews were recorded (only two participants did not agree with a recording). The scenario narrative was supported by visual representations of the content. For complexity reasons, the scenario was presented in condensed form, but the full text had been provided via email before. Subsequently, we presented our identified nine factors by giving examples and explaining their status quo 2010. We conducted the actual interview using the graphical interview guide with a timeline from 2010 to 2030. The goal here was to discuss the role of individual factors on the way towards the desirable scenario and to develop measures for the short-, medium- and long-term. The time horizon from 2010 to 2030 was created according to the time horizon of the Delphi survey: the next 5 years as short-term time horizon, until 2020 the medium–term horizon, and the phase until 2030 representing the long-term perspective.

4. Continuation

According to Quist & Vergragt (2006), follow-up of backcasting exercises is very important to actually use and implement the content that has been generated.
The results of our research have already been used at several occasions. Multiple workshops with stakeholders from the automotive industry were held. Here, the implications of the measures for the different stakeholder groups were further discussed.

DISCUSSION

Major Insights of the expert interviews

In this chapter we want to give insights into the most discussed topics of the expert interviews that were held to identify pathways to the desirable scenario. The three most discussed factors are 1) Customer preferences, 2) Changing market structure, and 3) Government intervention.

Customer preferences:
Overall, the key topics that were discussed within the factor of customer preferences are: 1) car ownership, 2) willingness to pay, 3) importance of origin of electricity for customers.
More than half of the interviewed experts´ comments were on the importance of car ownership in the future. A common understanding is that the importance of car ownership will be further reduced in the future. Numerous experts draw a comparison to the development in Japan, where many young people do not even own a driver’s license anymore. Related to this aspect is the importance of flexibility: The will to be flexible individually will ensure a certain level of ownership rates of cars.
One of the most discussed topics within the factor customer preferences is the willingness to pay and here especially the total cost of ownership (TCO), that are relevant within the area of electric mobility. Several experts view the price of electric vehicles as major criterion for customers to acquire such a vehicle. At this point, the linkage to the topic production costs for such cars becomes obvious.
The importance of total cost of ownership is mentioned by nearly half of the experts. A common argument here is that in order to be able to enter a mass market, competitive cost of ownership are viable for the success of electric mobility.
Another discussed topic is the importance of origin of electricity for customers. Here, dissent can be identified: While one part of the group estimates the origin of electricity for electric cars to be highly relevant for customers, another part of the experts commenting on this question believes the cost structure for electricity to be more important for customers than whether electricity for new drive concepts originates from renewable energies.

Changing market structure:
Within the field of market structure, the topics discussed most are 1) the role of new automotive companies on the way towards the desirable scenario, 2) the role of Asian companies, and 3) the allocation of value added between OEMs and suppliers.
The role of new companies within the automotive sector was discussed in a quite controversial manner. Most of the experts perceive the function of new players mainly as innovators in the short term, that are later acquired by or cooperate with established automotive OEMs or suppliers. One of the main reasons for such a process is a lack of competences in mass production of cars and a lack of financial resources. Despite the

fact that (a minority) expects new companies to play a major role in the long term as well, some experts expect innovative IT companies to become important in the automotive sector. Further, especially the marketing effect of new and innovative companies should not be underestimated with regard to spill-over effects on the products of established players.
Concerning the role of Asian automotive companies, many experts perceive especially Japanese companies to be ahead in terms of new power train technologies that are relevant for the achievement of the desirable scenario. Another much discussed issue was the emergence of Chinese companies that might change their role from being suppliers of rather simple automotive parts to full-scale OEMs that are starting to compete with innovative technologies from established companies in a variety of segments.
While most experts commenting on the relationship between OEMs and supplier do not expect substantial changes of value added between these two parties, other experts mention new opportunities for suppliers especially in the field of new mobility services.

Governmental intervention:
Concerning the factor of governmental interventions, the main topics discussed are 1) advancement of research and development, 2) buying incentives for customers and 3) advantages for electric vehicles in urban areas.
Overall, more than half of the interviewees commented on the question of whether industry should be supported by the government or not. The majority of experts dealing with this topic votes for industry support. Concerning the experts who comment on the issue of supporting basic research in the area of electric mobility, all are in favour of such a support.
The second main topic in the area of governmental support dealt with the question whether buying incentives should be granted for electric vehicles or not. Out of the 31 experts who made a statement related to this issue, 19 vote for it, 12 against it. Here, it becomes obvious that this topic is a major source of dissent among the experts. Similar to the discussion about industry support, several references are made to buying incentives in an international context.
The third major issue that was discussed in the area of governmental regulations was the question whether advantages for electric vehicles in urban areas like special driving lanes etc. should be granted or not. Out of the 16 experts commenting on this topic, the vast majority are in favour of such incentives, while the experts criticising such regulations mention questionable ecological advantages and socially unfair treatment of customers.

Generally, in can be observed that a variety of topics was discussed quite controversially. A holistic analysis for the relevant issues discussed was done. However, a presentation of the entire findings would go beyond the scope of this paper.

Methodological reflection of the Delphi-based backcasting approach

The method that we used in this study combined an innovative Delphi survey with individual semi-structured expert interviews. Our approach enables to both include a large number of different stakeholders and still having a structured process of how the results are analysed and further used. The importance of involving different stakeholders is also emphasized by Cuhls (2002). Moreover, the anonymity of the Delphi and the comforting atmosphere of personal interviews give interviewees the opportunity to comment on issues that they would otherwise not have commented on. This leads to a broad data pool of differing opinions and a multi-faceted view.
The Delphi method has much potential to be enlarged by further methods. Engels and Powell Kennedy (2007) discuss ways of how to enhance Delphi findings by including further methods into a study. A key difference to our case is that the follow-up interviews were used to rework the Delphi results instead of using them as a starting point for further analyses in a backcasting sense.
The combination of backcasting and Delphi has been executed by Höjer (1998) in a study concentrating on transport telematics in urban transport. Contrary to our approach of combining Delphi and backcasting, however, Höjer (1998) employed scenarios that had been developed within the research project and were exposed to repeated and structured

critique by experts in a Delphi-like way. The experts were asked to evaluate certain scenarios and give hints for potential changes or new content of the scenarios. By using the web-based real-time Delphi approach we were able to invite a broad number of participants to the study which enabled us to address experts from 15 different user groups. The idea to recruit the interviewees for the individual interviews from the Delphi panel clearly was an advantage, since all interviewees immediately knew what the discussions were all about.

So far, participatory backcasting approaches have been executed mostly with the help of workshops and focus group discussions in order to develop the paths towards desirable scenarios with the relevant stakeholders (Carlsson-Kanyama, Dreborg, Moll, & Padovan, 2008; Kok, Patel, Rothman, & Quaranta, 2006). In this respect, a focus group is a form of qualitative research, in which a group of people is asked about its perceptions, opinions, beliefs, and attitudes towards a product, service, concept, advertisement, idea, or packaging (Henderson, 2009). However, the emergence of results often remains unclear.

The aim of our backcasting exercise was to include a diverse group of stakeholders not only in the development of the scenarios, but also in the backcasting step itself while still applying a structured and transparent approach. Therefore, we employed a methodology of semi-structured, in-depth interviews with selected interviewees using a tailored interview guide for the backcasting interviews. The subsequent coding of the transcribed interviews allowed for a structured and transparent analysis of the discussed content.

LIMITATIONS AND CONCLUSION

Especially in the expert interviews, a variety of topics was discussed. While allowing for a holistic perspective on the factors that are relevant for the desirable scenario, the range of topics did not enable a detailed discussion of single topics. Moreover, the broad range of opinions in both the Delphi and the interview step did not lead to a consensus in all cases e.g. when developing the scenarios or elaborating on the measures that need to be taken in order to reach the desirable scenario. An initial aim of the study was to develop measures that are linked to a concrete point in time. Due to the fact that quite many different topics were included in the study and that a great variety of stakeholders was involved, the issues raised were covered in their breadth. This leads into the same direction of what Svenfelt et al. (2011) remark as a limitation in their study: It is often difficult to develop concrete pathways to the desirable scenario. Here, follow-up research could dig deeper concerning single details.

Backcasting has been applied using a number of different techniques. Mostly, however, focus groups were used to develop scenarios or measures on the pathway towards a desirable future. In our backcasting approach, we showed how (real-time) Delphis and guided interviews can be combined in order to tackle problems such as sustainable logistics and mobility in Germany in a very structured discussion.

Specifically, with the help of combining (real-time) Delphis and semi-structured in-depth interviews with subsequent coding, shortcomings of focus groups such as the suppression of alternative opinions could be circumvented. Furthermore, by using an internet-based real-time Delphi survey and individual interviews via telephone it was possible to include a sample of 140 experts in the Delphi step and 43 participants in the interviews, coming from 15 different groups in each case.

New research endeavours could combine several Delphis were the first survey develops scenarios as we used it in the study at hand. A following (real-time) Delphi survey could, in turn, be employed to evaluate measures according to their timeliness or importance.

REFERENCES

Armstrong, J. S. (2001). *Principles of Forecasting: A Handbook for Researchers and Practitioners*. Boston et al.: Kluwer Academic Publishers.

Carlsson-Kanyama, A., Dreborg, K. H., Moll, H. C., & Padovan, D. (2008). Participative backcasting: A tool for involving stakeholders in local sustainability planning. *Futures, 40*(1), 34-46.

Cuhls, K. (2002, July 11, 2002). *Participative foresight – How to involve stakeholders in the modelling process.* Paper presented at the Innovation Policy Conference, Brussels, Belgium.

Delbecq, A., Van de Ven, A. H., & Gustafson, D. H. (1986). *Group Techniques for Program Planning: a guide to nominal group and delphi processes*. Middleton: Green Briar Press.

Dreborg, K. H. (1996). Essence of backcasting. *Futures, 28*(9), 813-828.

Engels, T. C. E., & Powell Kennedy, H. (2007). Enhancing a Delphi study on family-focused prevention. *Technological Forecasting and Social Change, 74*(4), 433-451.

European Commission. (2001). *European Transport Policy for 2010: Time to Decide*. Brussels.

Federal Ministry of Economics and Technology. (2007). *Bericht zur Umsetzung der in der Kabinettsklausur am 23./24.08.2007 in Meseberg beschlossenen Eckpunkte für ein Integriertes Energie- und Klimaprogramm*. Retrieved from http://www.bmwi.de/BMWi/Navigation/Service/publikationen,did=228048.html.

Federal Ministry of Transport, Building and Urban Development. (2009). *German Federal Government's National Electromobility Development Plan*. Retrieved from http://www.bmvbs.de/cae/servlet/contentblob/27978/publicationFile/9729/national-electromobility-development-plan.pdf.

Gnatzy, T., Warth, J., von der Gracht, H. A., Darkow, I.-L. (2011). Validating an Innovative Real-Time Delphi Approach - A methodological comparison between real-time and conventional Delphi studies. *Technological Forecasting & Social Change* (accepted, corrected proof).

Henderson, N. R. (2009). Managing Moderator Stress: Take a Deep Breath. You Can Do This! *Marketing Research, 21*(1), 28-29.

Hensher, D. A., & Button, K. J. (Eds.). (2003). *Handbook of Transport and the Environment*. Amsterdam: Elsevier.

Höjer, M. (1998). Transport telematics in urban systems--a backcasting Delphi study. *Transportation Research Part D: Transport and Environment, 3*(6), 445-463.

Köhler, J., Whitmarsh, L., Nykvist, B., Schilperoord, M., Bergman, N., & Haxeltine, A. (2009). A transitions model for sustainable mobility. *Ecological Economics, 68*(12), 2985-2995.

Kok, K., Patel, M., Rothman, D. S., & Quaranta, G. (2006). Multi-scale narratives from an IA perspective: Part II. Participatory local scenario development. *Futures, 38*(3), 285-311.

Nieuwenhuis, P., Wells, P., & Vergragt, P. J. (2004). Technological Change and Regulation in the Car Industry (pp. 5-11): Greenleaf Publishing.

Quist, J., & Vergragt, P. (2006). Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures, 38*(9), 1027-1045.

Svenfelt, Å., Engström, R., & Svane, Ö. Decreasing energy use in buildings by 50% by 2050 -- A backcasting study using stakeholder groups. *Technological Forecasting and Social Change, In Press, Corrected Proof*.

Urry, D. (2004). The 'system' of automobility.". *Theory Culture & Society, 4-5*(21).

von der Gracht, H. A., & Darkow, I.-L. (2010). Scenarios for the logistics services industry: A Delphi-based analysis for 2025. *International Journal of Production Economics, 127*(1), 46-59.

von der Gracht, H. A., Gnatzy, T., Darkow, I.-L., Gordon, T. J., & Glenn, J. (2011). *New Frontiers in Delphi Research – Experiences with Real Time Delphi in Foresight*. Paper presented at the WorldFuture 2011.

Zapata, C., & Nieuwenhuis, P. (2010). Exploring innovation in the automotive industry: new technologies for cleaner cars. [Article]. *Journal of Cleaner Production, 18*(1), 14-20.

DELPHI BASED SCENARIOS ON THE FUTURE OF TRANSPORT INFRASTRUCTURE – AN INDUSTRY'S LONG-TERM OUTLOOK UNTIL 2030

Steffen Schuckman[3], Tobias Gnatzy, Dr. Heiko A. von der Gracht, Dr. Inga-Lena Darkow
Center for Futures Studies (CEFU)
Supply Chain Management Institute (SMI), EBS Business School, Wiesbaden, Germany

1. INTRODUCTION

Transport infrastructure is the backbone of global trade, cross-national supply chains and logistics networks. Already in 1971, McDaniel (1971) judged the issue of transportation as a major force in our society. At present, Loorbach et al. (Loorbach, Frantzeskaki et al. 2010) emphasize that transport infrastructure provides crucial service to society and is the basis for investments and planning in industry and trade. The economic relevance of transport infrastructure is also supported by Stalk (2009) who states that a lack of infrastructure capacity can significantly affect economic growth. Stalk mentions that the current global economic recovery strongly bases on the availability of enough capacity of logistics-hubs and networks like ports, highways, railways and airports.

Demand oriented transport infrastructure planning as well as the provision of adequate financial resources is crucial to markets and economies. An a global level, by 2030 it is estimated that more than US$41 trillion (thereof US$7.8 trillion for road and rail, and US$1.6 trillion for air/sea-ports, period 2005-2030) will be required for infrastructure development during the next 25 years to modernize obsolescent systems and meet expanding demand (BoozAllenHamilton 2007). While the basic supply of transport infrastructure and related financing strategies is essential to ordinary logistics and mobility demands, the challenge of creating international competitiveness in transport infrastructure becomes more and more evident. Countries need a well-developed transport infrastructure to compete internationally and to provide a high level of accessibility in terms of traffic and goods flows (Banister and Berechman 2001). Furthermore, finding an acceptable balance between promoting economic growth through the expansion of transport infrastructure and protecting the environment will stay a critical issue in the future. While economic growth is often defined as a major objective, it is also critical to understand how projects will affect the environment (UNESCAP 2006).

Nevertheless, stakeholders are aware of how vulnerable the economy is when transport infrastructure is not prepared for the future challenges. Taking the highly dynamic and challenging environment into account, stakeholders cannot prepare for the one future to come. Decision makers have to take deep uncertainty into account, e.g. uncertainties about future 'external' developments, future transportation demand, mode choices, and how these choices affect accessibility, environment, and safety (Marchau, Walker et al. 2010). It's the manifold portfolio of possible future developments which has to be addressed via reasonable approaches and valid methodologies enabling broaden planning perspectives (Wright and Goodwin 2009). One of the most adequate methods for addressing different possible future developments, long-term planning and decision making in uncertain situations is the scenario planning approach. Many applications in science and practice underline that scenario planning presents one of the most appropriate long-term planning tools (Phelps, Chan et al. 2001). The scenario planning method has been especially developed to support policy-makers and business leaders, facing decisions with uncertain future outcomes (Volkery and Ribeiro 2009).

In this paper, we describe four "hot topic" scenarios which are based on an innovative web-based real-time Delphi survey approach. The integration of the Delphi technique into scenario study is recommended due to increasing creativity, objectivity and credibility regarding the developed scenarios (Nowack, Endrikat et al. 2011). The "hot topic" scenarios contribute to single thematic aspects and strategic questions in a focused and condensed way. Our scenarios can support decision makers and planners in defining strategies or in testing the robustness and appropriateness of strategies that are already

[3] To correspond to (steffen.schuckmann@ebs.edu).

in place. Furthermore, we present managerial as well as governmental implications. We were guided by the main research question of *how will probable, possible, desirable and surprising scenarios of the future of transportation infrastructure 2030 look like and what are their implications for today's decision makers*.

2. LITERATURE REVIEW

Within the scope of our literature review, we identified several academic articles and reports which discuss scenario and long-term planning jointly with transport infrastructure topics and clustered them regarding their orientation. Scenario planning and scenario building are already well established in decision making (Stead and Banister 2003). While the application of scenario planning and scenario building is relatively new to the business environment, foresight techniques and scenario planning were early applied within the field of infrastructure (Bradfield, Wright et al. 2005). Loorbach (Loorbach, Frantzeskaki et al. 2010) recently revealed that research in the field of infrastructure systems has a long tradition. They also found that research generally "has focused on a single sector, has often been mono-disciplinary in character (technological, economic, behavioral), and focused on specific system elements (rather than the whole system) and their optimization (rather than fundamental change)" (Loorbach, Frantzeskaki et al. 2010, p.1196).

Our literature review provides an overview of the most relevant governmental and academic literature on scenario planning in the context of transport infrastructure. Only five academic articles, in transport infrastructure with scenario and long-term planning, could be identified. All articles present Delphi technique as preferred and adequate research methodology to address the individual research objectives. The publications mostly exhibit a qualitative focus, while applying narrative descriptions (Svidén 1988; Höjer 1998; Ubbels, Rodenburg et al. 2000; Shiftan, Kaplan et al. 2003). Gray et al. (Gray and Helmer 1976) and Shiftan et al. (Shiftan, Kaplan et al. 2003) focus on regional scale level, e.g. California and Tel-Aviv. Others concentrate on mono-disciplinary approaches in terms of information technology or sustainability (Svidén 1988; Höjer 1998; Shiftan, Kaplan et al. 2003). The work of Ubbels et al. (Ubbels, Rodenburg et al. 2000) count for an exception since presenting a more holistic work in terms of scale level and multi-discipline. Nevertheless, they focus on quantitative measures and limit their implications to economic aspects.

Still in 2006, Bergmann et al. (Bergman, Viljainen et al. 2006) state that hardly any scenario study exists that addresses the decision making process within companies. We can observe that the largest and most comprehensive studies on the future of transport infrastructure, are published by governmental organizations or related associations. These studies mostly intend to support governmental and public decision makers. Of course, these reports can be applied by business leaders as well but hardly any governmental induced report explicitly takes managerial decision making processes into consideration. The report of the European Foundation for the Improvement of Living and Working Conditions (EF 2008) counts for an exception due to its clear objective to explicitly address policy makers as well as strategic decision makers within companies. The governmental and associations induced reports generally have a regional focus, e.g. OECD countries, UK or European Union, and therefore miss to address global concerns. Only Krail et al. (Krail, Schade et al. 2007) and the World Energy Council (WEC 2007) present a global approach but strongly focus on policy recommendations. Peterson et al. (Petersen, Enei et al. 2009) present an extensive study on transport scenarios with a 20- and 40- year horizon. They apply long-term scenario forecasting by applying Delphi technique and include modeling work as well case studies. They developed exploratory and "computed" scenarios for 2030 and 2050. Peterson et al. merely address the issue of transport policy making within the EU and additionally miss to address business and management implications of transportation infrastructure forecasting. The European Community released the "Foresight for transport" report in 2004, which is also an extensive study applying Delphi technique as well as extrapolative and quantitative methods. But it also misses to address global perspectives and strongly concentrates on policy making.

However, our literature review revealed that no comprehensive scenarios are available based on an (1) extensive globally conducted survey, giving an (2) answer on generally leading questions, covering future "hot topics", while taking (3) also corporate decision making into consideration. Our paper aims to close this research gap by presenting relevant scenario which can be used as a basis and starting point especially for corporate but political strategy development as well.

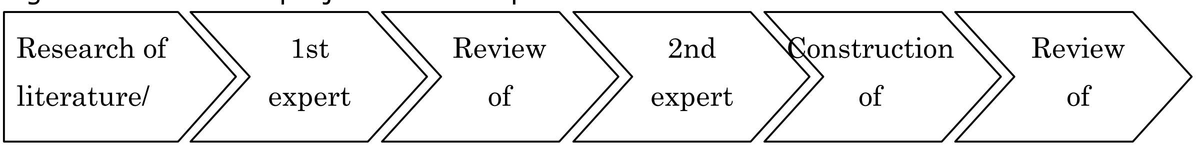
3. METHODOLOGY, RESEARCH DESIGN AND ANALYSIS

The development of Delphi-based scenarios is an approach that has been explicitly recommended by numerous authors. The Delphi process is easy to integrate into the scenario development process and Delphi delivers valuable, valid, and reliable data for scenario construction (Rikkonen, Aakkula et al. 2006). The Delphi method is a judgmental forecasting procedure in the form of an anonymous, written, multi-stage survey process (Rowe, Wright et al. 1991).

The real-time Delphi approach we applied is an innovative and improved evolution of the well-known conventional Delphi approach, based on the RAND Corporations' logic (Dalkey 1969), and refutes earlier mentioned shortcomings, e.g. expert panel biases or time scale disadvantages (Scapolo 2005). Our approach enhances expert availability, reduces drop-out-rates, speeds up the hole process and adds additional functionalities like an 'ease-of-use facilitator portal', a 'consensus portal', and a 'graphical real-time feedback' (Gnatzy, Warth et al. 2011; von der Gracht, Gnatzy et al. 2011).

First, we developed 16 projections by proceeding several expert workshops, taking advice from external industry experts and gathering secondary data through extensive desk research. Afterwards, 104 designated experts from academia (24%), practice (55%), politics (10%), and associations (11%) from 29 countries around the world were identified and recruited. Third, the projections were evaluated online by the experts in terms of probability and desirability of occurrence as well as impact on the transport and logistics industry. In addition to their quantitative assessments, the panelists were able to provide qualitative statements, which supported their numerical estimations and to discuss relationships between factors shaping future developments. Afterwards, an interim analysis of the statistical group opinion was generated. Finally, the experts were asked to revise their first round estimations based on the feedback of the interim results in real time and the given arguments as well. Based on the assessments and more than 1,210 collected comments, which we proceeded via an open coding process (Corbin 1990), we developed scenarios-"fields" for the future of the global transportation infrastructure in 2030.

Figure 1: Process of projection development



Analysis

We estimated a Delphi runtime of eight weeks as adequate enough to gain valuable results. The experts were reminded to participate or to reassess earlier results after a survey period of four weeks. Within the whole survey period of eight weeks, experts took part on 3.2 Delphi rounds in average, i.e. first and second round per thesis as well as 1.2 further logins for revision purposes. In total, 1,210 written comments, which represent the qualitative assessments of our future projections, were provided. That counts for an average of 11.6 given comments per expert.

The quantitative results reveal that 12 out of 16 projections have an average estimated probability of occurrence of more than 50%. It can be observed that all of the projections have an average industry impact of nearly 4 out of 5, which equals "high". In all cases, the standard deviation in expert assessments decreased between the first and the last round. Consequently, the Delphi process ensured that participating experts followed an agreement process over time and with ongoing discussions. Occurrence of the agreement process is also reflected in the interquartile ranges (IQR) which decreased in all cases.

As already reported, the panelists supported their assessments on probability of occurrence, impact on the industry and desirability of our 16 future projections by providing 1,210 comments. Thereof, 565 qualitative arguments could be identified, applying to the assessment of the probability of occurrence. We analyzed and categorized these arguments by following an open coding process (Corbin 1990). Within this open coding process, we identified labeled and categorized variables which influenced the individual experts' assessment. Afterwards, we grouped the resulting codes to 'low or high probability' categories. In total, we were able to identify 182 codes, whereof 93 codes occurred several times and 89 codes occurred just once.

Development of scenarios
Our major contribution is to provide plausible, consistent and valid scenarios. In order to meet these quality requirements, we used the coding results to create expert-knowledge based scenario texts which consider important drivers regarding the occurrence of a certain scenario. Thereby, we integrated the expert knowledge into the scenario development process. Recent research results revealed that the approach applied, would be appropriate to develop those verified scenarios (Shiftan, Kaplan et al. 2003; Rikkonen, Aakkula et al. 2006; von der Gracht and Darkow 2010).

4. SCENARIO ANALYSIS

EP	Estimated probability of occurrence (metric scale 0-100%)	✓✓	Strong consensus (IQR of <= 20)
I	Impact on industry, if occurred (5pt-Likert scale)	✓	Moderate consensus (IQR of 20-25)
D	Desirability of occurrence (5pt-Likert scale)	×	Moderate dissent (IQR of 25-30)
IQR	Interquartile range	××	Strong dissent (IQR of >=30)
ΔSD	Change (%) of standard deviation: first vs. final value		

Table 1: Results Scenario "Supply & Demand"

Projections 2030	Delphi statistics				
P1: There is no longer a shortage of transport infrastructure since sufficient investments have been made.	EP	I	D	IQR	ΔSD
	30.2	4.1	4.2	✓✓ (15)	-16.04
P2: Transport infrastructure development strongly focuses on urban areas, while rural areas are neglected.	EP	I	D	IQR	ΔSD
	68.4	3.7	2.9	✓✓ (20)	-24.83
P3: Infrastructure shortages have forced the division of megacities into decentralized, autonomous "sub-cities".	EP	I	D	IQR	ΔSD
	49.6	3.6	3.0	×× (30)	-9.44

Scenario "Supply & Demand": Economy and society face a shortage of transport infrastructure in 2030 due to insufficient investments. Demand of adequate capacity significantly exceeds supply in a way that transport infrastructure operators, users and owners get frustrated since supply chains, logistics clusters and transportation corridors are not implemented and "activated" as markets, consumers and passengers require. The trend of "mega-urbanization" has resulted in a situation where transport infrastructure development strongly focuses on markets and consumers in urban areas, while rural areas and related people are neglected. Megacities find themselves at the crossroads whether infrastructure shortages, which regularly result in a high level of congestion, have forced the division of megacities into decentralized, autonomous "sub-cities".

Implication: Transport infrastructure operators, users and owners should be prepared to operate in imperfect transport infrastructure systems and therefore need to realize flexible planning structures. Additionally, they should investigate their business plans and strategies regarding expected and required transport infrastructure systems.

Table 2: Results Scenario "Finance"

Projections 2030	Delphi statistics				
P4: In emerging countries, there is more capital available to invest in transport infrastructure than in industrialized countries.	EP	I	D	IQR	ΔSD
	52.5	3.7	3.1	×× (30)	-12.82
P5: Financing the maintenance of transport infrastructure is more difficult than attracting investments in new infrastructure.	EP	I	D	IQR	ΔSD
	65.1	3.9	2.1	×× (30)	-16.48
P6: Financial pressure on governments has become so intense that almost all investment in transport infrastructure has been shifted to the private sector.	EP	I	D	IQR	ΔSD
	54.9	3.9	2.7	×× (30)	-9.23
P7: Governments are no longer able to contribute to the funding of local transport infrastructure, thus user-based financing structures are prevalent.	EP	I	D	IQR	ΔSD
	52.2	3.7	2.4	×× (30)	-4.49
P8: International transport infrastructure is controlled by private investment funds, which are strategic drivers of large-scale transport infrastructure projects.	EP	I	D	IQR	ΔSD
	60.7	3.8	3.0	✓ (25)	-7.90
P9: Strong regulatory measures, such as road tolls and congestion charges, compensate for the increased need to invest in transport infrastructure.	EP	I	D	IQR	ΔSD
	60.1	3.9	3.5	✓✓ (20)	-13.79

Scenario “Finance”: The general challenge of financially weak governments has led to a situation where it is more difficult to finance maintenance projects than to invest in new infrastructure projects, which turn out to be a lot more promising in terms of revenues. Road tolls and congestion charges are the most reasonable way of sourcing and lead to better capacity exploitation. Additionally, public-private-partnerships and privatization come up due to attractiveness but transport infrastructure still remains to be public mission as well as political playground.

Implication: Since governments will be in charge of transport infrastructure procurement, they have to explore and assess new financing models for transport infrastructure in order to realize a sustainable basis for future development. Operators, users and owners primarily have to assess the willingness of a government to invest in transport infrastructure and the potential for rising revenues on user-based revenue models.

Table 3: Results Scenario "Competitiveness"

Projections 2030	Delphi statistics				
P10: Transport infrastructure is still a key element of the basic services of an economy, but is no longer a deciding factor in the competition between countries to attract investment.	EP	I	D	IQR	ΔSD
	41.7	3.7	2.8	✓✓ (20)	-10.85
P11: Industrialized countries have lost their competitive advantage over emerging countries in terms of transport infrastructure.	EP	I	D	IQR	ΔSD
	41.1	3.8	2.9	✓✓ (20)	-12.76
P12: Digital infrastructure (ICT) has become a stronger driver of economic growth than transport infrastructure.	EP	I	D	IQR	ΔSD
	59.6	3.8	3.4	✓✓ (20)	-13.84
P13: The success of a logistics cluster depends on the close collaboration of industry, government and academia, in addition to	EP	I	D	IQR	ΔSD
	77.5	4.0	4.2	✓✓ (20)	-8.26

advanced transport infrastructure.					

Scenario "Competitiveness": Information and communication technology (ICT) are a major booster of economic success and seem to be a stronger driver of economic growth than transport infrastructure itself. Fully integrated and widely available ICT systems enable cutting-edge transport and supply chain solutions and significantly enhance competitive advantage by creating seamless intermodal interfaces. Nevertheless, basic transport infrastructure remains a critical precondition regarding the fulfillment of basic economic needs. Additionally to the competitive "effects" of ICT, clusters built from close collaborations of industry, academia, and government benefit regions by activating new potentials in transportation infrastructure development.

Implication: It is vital for governments to safeguard economic competitiveness by maintaining, upgrading and expanding transport infrastructure, e.g. full implementation of ICT systems. For infrastructure operators, users and owners, it is vital to consider active collaboration with governments and academia via joining e.g. logistics clusters, for example.

Table 4: Results Scenario "Sustainability"

Projections 2030	Delphi statistics				
P14: A decrease in environmental awareness and regulation has accelerated the realization of large-scale transport infrastructure projects, boosting economic growth.	EP	I	D	IQR	ΔSD
	29.0	3.85	1.9	✓✓ (20)	-19.85
P15: Transport infrastructure operators are obliged to participate in emission trading systems to obtain pollution permits.	EP	I	D	IQR	ΔSD
	68.8	3.9	3.6	✓✓ (20)	-10.59
P16: The environmental costs caused by infrastructure development have become a serious deterrent to investments for which there is otherwise a good economic case.	EP	I	D	IQR	ΔSD
	55.6	3.9	2.6	✓ (25)	-3.49

Scenario "Sustainability": Transport infrastructure is increasingly assessed on environmental compatibleness, in addition to its ability to stimulate economic growth. Environmental costs caused by infrastructure development are a serious deterrent to investments for which there is otherwise a good economic case. Specific economic concepts, enabling win-win-situations, have been evolved, wherein economic and environmental issues are considered likewise regarding infrastructure projects and business plans. Infrastructure operators and users are obliged to participate in emission trading systems to obtain pollution permits as emission trading systems gain more and more relevance.

Implication: When policy makers and business makers assessing the environmental compatibility of transport infrastructure solutions, both harmful environmental effects and environmental benefits need to be considered. Furthermore, the entire life cycle of construction, operation and deconstruction has to be taken into account.

CONCLUSION
Our research closes a research gap with respect to scenario development in the transportation infrastructure industry on a global perspective. We were guided by the question *how will the future of transportation infrastructure 2030 look like and what are their implications for today's decision makers*. By conducting Delphi-based scenario research, expert knowledge could be aggregated to identify four substantial "hot topic" scenarios. Furthermore, our internet-based Delphi method combines quantitative as well as qualitative research approaches to ensure a high level of scientific rigor and thus refutes earlier mentioned shortcomings, e.g. expert panel biases or time scale disadvantages.

Our Delphi-based scenarios can be used as a basis and starting point especially for corporate but political strategy development as well, which is the main managerial and governmental contribution of our work. Another contribution is the identification of fundamental implications for action regarding different challenges in the disciplines of policy and business making. The scenarios might be used to update or develop new strategies or to test existing strategies regarding their future-robustness and adequacy.

Our work includes some limitations, which we would like to discuss here. One main concern is related to the scenario process, which was limited to the scenario development. The transfer of the outcome is limited to the presentation of managerial and governmental implications. Our scenarios rather aim to address global and top-level challenges than to contribute to specific regional difficulties. We are aware of the situation that policy and decision making in emerging and developing countries, compared to developed countries, often require different concepts and approaches.

Future in-depth research in this field could focus on challenging topics such as information and communication technologies (ICT), human resources, and development of infrastructure and logistics clusters. Furthermore, we focused on experts from the transportation and logistics industry. We expect the extension of the expert panel as promising in order to consider further research topics from various industry perspectives like consumer goods, automotive, raw materials, for example.

KEYWORDS:
Transportation infrastructure, real-time Delphi, future scenarios, future planning

REFERENCES:
Banister, D. and Y. Berechman (2001). "Transport investment and the promotion of economic growth." Journal of Transport Geography **9**(3): 209-218.
Bergman, J., S. Viljainen, et al. (2006). "Managing the exploration of new operational and strategic activities using the scenario method--assessing future capabilities in the field of electricity distribution industry." International Journal of Production Economics **104**(1): 46-61.
BoozAllenHamilton (2007). "Lights! Water! Motion!".
Bradfield, R., G. Wright, et al. (2005). "The origins and evolution of scenario techniques in long range business planning." Futures **37**(8): 795-812.
Corbin, J. S., A. (1990). "Grounded theory research - Procedures, Canons and Evaluation Criteria." Qualitative Sociology **13**.
Dalkey, N. (1969). "An experimental study of group opinion: The Delphi method." Futures **1**(5): 408-426.
EF (2008). Trends and drivers of change in the EU transport and logistics sector: Scenarios. Dublin, European Foundation for the Improvement of Living and Working Conditions.
Gnatzy, T., J. Warth, et al. (2011). "Validating an Innovative Real-Time Delphi Approach - A methodological comparison between real-time and conventional Delphi studies." Technological Forecasting & Social Change (accepted, corrected proof).
Gray, P. and O. Helmer (1976). "The Use of Futures Analysis for Transportation Research Planning." Transportation Journal **16**(2): 5-12.
Höjer, M. (1998). "Transport telematics in urban systems--a backcasting Delphi study." Transportation Research Part D: Transport and Environment **3**(6): 445-463.

Krail, Schade, et al. (2007). Outlook for Global Transport and Energy Demand. Karlsruhe, Germany.

Loorbach, D., N. Frantzeskaki, et al. (2010). "Introduction to the special section: Infrastructures and transitions." Technological Forecasting and Social Change **77**(8): 1195-1202.

Marchau, V. A. W. J., W. E. Walker, et al. (2010). "Dynamic adaptive transport policies for handling deep uncertainty." Technological Forecasting and Social Change **77**(6): 940-950.

McDaniel, D. E. (1971). "Transportation forecasting: A review." Technological Forecasting and Social Change **3**: 367-389.

Nowack, M., J. Endrikat, et al. (2011). "Review of Delphi-based scenario studies: Quality and design considerations." Technological Forecasting and Social Change **In Press, Corrected Proof**.

Petersen, Enei, et al. (2009). Report on Transport Scenarios with a 20 and 40 year Horizon. Copenhagen, Denmark, DG TREN.

Phelps, R., C. Chan, et al. (2001). "Does scenario planning affect performance? Two exploratory studies." Journal of Business Research **51**(3): 223-232.

Rikkonen, P., J. Aakkula, et al. (2006). "How can future long-term changes in finnish agriculture and agricultural policy be faced? defining strategic agendas on the basis of a delphi study." European Planning Studies **14**(2): 147-167.

Rowe, G., G. Wright, et al. (1991). "Delphi: A reevaluation of research and theory." Technological Forecasting and Social Change **39**(3): 235-251.

Scapolo, F. (2005). "New horizons and challenges for future-oriented technology analysis--The 2004 EU-US seminar." Technological Forecasting and Social Change **72**(9): 1059-1063.

Shiftan, Y., S. Kaplan, et al. (2003). "Scenario building as a tool for planning a sustainable transportation system." Transportation Research Part D: Transport and Environment **8**(5): 323-342.

Stalk, J. G. (2009). "The Threat of Global Gridlock." Harvard Business Review **87**(7/8): 126-129.

Stead, D. and D. Banister (2003). "TRANSPORT POLICY SCENARIO-BUILDING." Transportation Planning and Technology **26**(6): 513-536.

Svidén, O. (1988). "Future information systems for road transport: A Delphi panel-derived scenario." Technological Forecasting and Social Change **33**(2): 159-178.

Ubbels, Rodenburg, et al. (2000) "A Multi-layer Scenario Analysis for Sustainable International Transport."

UNESCAP (2006). Sustainable infrastructure in Asia. Bangkok, United Nations ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC.

Volkery, A. and T. Ribeiro (2009). "Scenario planning in public policy: Understanding use, impacts and the role of institutional context factors." Technological Forecasting and Social Change **76**(9): 1198-1207.

von der Gracht, H. A. and I.-L. Darkow (2010). "Scenarios for the logistics services industry: A Delphi-based analysis for 2025." International Journal of Production Economics **127**(1): 46-59.

von der Gracht, H. A., T. Gnatzy, et al. (2011). "New Frontiers in Delphi Research - Experiences with Real Time Delphi in Foresight. Conference Volume of the WorldFuture 2011,Vancouver, Canada." **In Press, Corrected Proof**.

WEC (2007). Transport Technologies and Policy Scenarios to 2050. London, World Energy Council.

Wright, G. and P. Goodwin (2009). "Decision making and planning under low levels of predictability: Enhancing the scenario method." International Journal of Forecasting **25**(4): 813-825.

COOPERATION BETWEEN LOGISTIC SERVICE PROVIDERS AND SHIPPERS ON MAKING TRANSPORTATION SUSTAINABLE

R. Pieters[1], H-H. Glöckner[1], S.W.F. Omta[2] and S.J.C.M. Weijers[1]

[1] University of Arnhem and Nijmegen, the Netherlands
[2] Wageningen University and Research Centre, the Netherlands
Reinder.Pieters@han.nl

ABSTRACT
This paper describes Dutch Logistic Service Providers attitudes towards sustainability and how they translate this into business practise. This is done by looking at what Logistic Service Providers say what they are doing or intend to do to improve sustainability for their transport services.

INTRODUCTION
Sustainability is becoming an important aspect for Logistic Service Providers anywhere. But how do the Logistic Service Provider and the shipper work together to make the chain more sustainable? This research investigates the relationship between the Logistic Service Provider and the shipper to make transportation more sustainable. The focus lies on how (Dutch) Logistic Service Providers handle the practical aspects of sustainability in order to achieve a higher level of sustainability. Do they opt for internal solutions (e.g. fleet replacement or ensuring that their chauffeurs drive more environmentally friendly) or for external solutions (e.g. setting up new networks or improving the cooperation with shippers or business competitors)? Our assumption is that solutions involving external partners require more effort than internal solutions but are more constructive.

RESEARCH METHODOLOGY
To answer these questions this research focuses on the leading Dutch Logistic Service Providers, due to their size or because they are forerunners in making transportation more sustainable. The first group consists of the fifty largest Logistic Service Providers operating in the Netherlands and were found in the top 50 of 2011 (Dijkhuizen, 2011). The second group consists of 60 Logistic Service Providers who participated in the award scheme "lean and green" between 2008-2010 (website Connekt).

The first group covers those Logistic Service Providers who, due to their size, can be considered to dominate the Dutch market and the second group covers the frontrunners for sustainable freight transportation in the Netherlands. First the websites of these Logistics Service Providers were scrutinized for information on sustainability. If no information was found, specific questions were asked by email on their standpoint on sustainability. All emails were quickly responded and the answers provided covered the questions

These results were compared with the answers respondents have given to a web survey which was held to investigate Logistic Service Providers and their attitude on sustainability in 2010. A request to participate in this survey was sent to 82 Logistic Services Providers, who have connections with our University through work placements schemes etc. 61 Accepted this request and of these 41 successfully filled in the survey completely. There is an overlap between the three target groups: 22 of the top 50 also participated in the "lean and green" award and 9 of the top 50 were also respondents of the survey. The web survey contains 14 respondents who were also in the top 50 and 18 who participated in the lean and green award scheme. 12 participants were part of both lists at the same time. The results are what the Logistics Service Providers say what they are doing to increase sustainability; what they are actually doing will be the subject of a next research.

THE ECOLOGICAL IMPACT OF THE TRANSPORT SECTOR

What makes freight transportation services sustainable is altogether not clear. So it follows that what makes a Logistic Service Provider more sustainable is not clearly cut. This could be due to a lack of a generally accepted definition of sustainable transportation (Pezzey, 1997). The definition of the Brundtland Commission (World Commission, 1987) is often taken as the basis for a definition (Jeon and Amekudzi, 2005), but this is difficult to translate into hard, measurable facts. As most trucks still employ an implosion engine, it could be stated that every litre of gasoline used for transportation today will not be available for future generations. So the Brundtland based definitions fail to be realistic and usable (yet).

When discussing sustainable transportation, the attention focuses on reducing exhaust gases. The main exhaust gases are carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (PM) (Francke, Annema and Wouters, 2009). There are more polluting exhaust gases concerning transportation like carbon monoxide (CO) and hydrocarbons (HC) (Meulen and Kindt, 2010), but these two gases were never mentioned on the research websites or by the respondents of the survey.

When discussing sustainable transportation, almost all attention in literature on sustainable freight transportation, (Dutch) government information on this subject and in the researched target groups is concentrated on CO_2 reduction. The other gases are hardly mentioned. As for the transport sector itself, just two Logistic Service Providers mention the four main gases, but do not show how they are trying to reduce all of them. As for this research, it was decided to follow this lead as well and to concentrate on CO_2.

In 2008, transportation is responsible for 21% of all CO_2 production within the Netherlands. The main part (79%) of this figure is taken up by road transport (private and freight). The remainder is divided amongst inland shipping (5%), air transportation (2%) and sea transport (14%). Within road transport, freight transport has a share of 36% (Meulen and Kindt, 2010). These figures show that the Dutch freight transport sector does produce a considerable amount (6%) of CO_2 and that Dutch Logistic Service Providers should consider their responsibility to control, or even better lower, the amounts of CO_2 produced. This responsibility is certainly taken up by the transport sector. Within the top 50 41 (82%) Logistic Service Providers mention sustainability as one of their company's goals on their websites. Those who did not mention sustainability were contacted and asked if they could provide additional information. Three of them did reply and based on their information the number of Logistics Service Providers who endorse sustainability has risen to 43 (86%). This equals the results of the web survey. Here 36 respondents (88%) stated that they endorse sustainability. These numbers are high! It can be stated that sustainability has become one of the major aspects influencing Logistic Service Providers' behaviour. It also shows that within the transport sector sustainability is not a unique selling point anymore. It has become a common feature.

SUSTAINABILITY AND SHIPPERS

But how important is sustainability for the customers of Logistic Service Providers?

A survey of Van der Meulen and Kindt (2010) amongst shippers found that they used certain criteria when selecting a Logistic Service Provider. The main criteria were price, reliability, service, sustainability and innovation. When asked to rank these criteria, the results were in favor of price with sustainability far below (see table 1). This choice is supported by literature which often states that the choice for a logistic aspect, such as transportation, is usually determined by two things:

SELECTION CRITERIA	WEIGHT PRICE =100
PRICE	100
RELIABILITY	94
SERVICE	72
SUSTAINABILITY	45
INNOVATION	33

Table 1 main selection criteria according to shippers

1. effectiveness like speed and reliability and
2. efficiency (low cost) (Christopher, 2005, Visser, 2010).

The web survey gives a similar impression. 32 (78%) of the respondents say cost is the most important issue with transportation and 34 (83%) do not think that the customer is willing to pay for sustainability.

Simply put, the customer especially requires "more value for less money" (Dorp, Kempe and Commandeur, 1992 p 23). The question is whether in the current era this is still valid. There is a trend amongst (final) customers to demand a higher level of socially responsible behavior from the supply chain partners (Maloni and Brown, 2006).

The portfolio model of Kraljic (1983) can be used to understand the shipper's choice better. Kraljic determines a item purchased by four criteria:

KRALJIC'S LABEL	MAIN SELECTION CRITERIA	DECISION
Leverage Items	Price	the product or service purchased determines the final price of the end product substantially. The purchaser will opt for the lowest cost.
Strategic Items	Quality	one specific aspect needs absolutely to be fulfilled by the item or service purchased.
Bottleneck Items	Availability	this product or service will not (always) be available. The purchaser will have to acquire potential sources for this product or service.
Non Critical Items	Nothing specific	As nothing specific determines this purchase, the purchaser's decision is not clearly cut.

Table 2 purchasing transport service and the portfolio model of Kraljic

Transportation cost takes up 10% till 25% of the overall costs for a product (Goor and Ploos van Amstel, 2009). The higher this percentage, the more transportation will become a leverage item with price as the main determining factor. Reliability is a quality aspect and makes transport a strategic purchase item. Transportation is rarely seen as a bottleneck item. Only if a transport requires vehicles with very specific conditions, due to the size or weight of the transported item. So this aspect can be ignored. For those shippers for whom transportation is not determined by these three aspects, nothing specific can be said.

Sustainability could make transportation more expensive (specific engines, new software may have to be bought etc.) or lengthen the delivery time (alternative modes for road transportation can take longer). Both aspects conflict with the two main aspects for transportation as seen by the shipper (Christopher, 2005). For sustainability to become an aspect of a strategic item some things will have to change:

- sustainability is enforced by government regulation;
- sustainability is set as a priority by the (final) customer or
- sustainability is taken to the top of the shipper's company values.

If nothing really will change, sustainability will just be a side aspect beside the main two criteria when drawing up Service Level Agreements (SLA) when selling or purchasing transport services.

AWARD SCHEMES

Hardly any specific information is to be derived from the information on the websites of the Top 50 on how the Logistic Service Providers want to achieve their goals on sustainability. What can be found are the networks or award programs in which they cooperate. Many awards programs have been set up to encourage and support sustainability within the transport sector. They offer the participants a chance to be compared to a standard and competitors. For customers and interested stakeholders an award scheme creates trust on the Logistic Service Provider's performance in the field of sustainability. The web survey found that 22 (54%) of the respondents believe award schemes form an essential part of the shipper's appreciation for Logistic Service Providers' level of sustainability.

For the transport sector, the website of the Environmental Forum registers 61 awards schemes for the UK alone. In the Dutch top 50, many Logistic Service Providers have joined international environmental award schemes like e.g.: Dow Jones Sustainability World and Europe Index (8%), World Business Council for Sustainable Development (14%) or United Nations Global Compact (24%). Other schemes which were mentioned are the FTSE4Good Global Index (2%), FLEXpledge (2%), Carbon Trust Standard (2%), Green Supply Chain Award (2%), Electronic Industry Citizenship Coalition (2%) and Responsible Care® (2%). Some awards are linked to specific industries. For example, the goal of Responsible Care® is to seek continuous improvement in health, safety and environment of the chemical industry's stakeholders (website ICCA). Five companies (10%) have joined more than one international environmental award scheme. Taking this into account, there is a participation rate of 42% for the top 50 Logistic Service Providers for international environmental award schemes.

For the top 50 companies, the involvement rate in international environmental award schemes is for the numbers: 1-10 (90%); 11-20 (50%); 21-30 (40%); 31-40 (20%) and 41-50 (10%). It seems that award schemes are particularly interesting for the larger Logistic Service Providers. Looking at the national origin of the Logistic Service Provider 14 (74%) of the 19 Non-Dutch companies have joined an international award scheme compared to 7 (23%) of the 31 Dutch companies. Beside these award schemes, 14 Logistic Service Providers (28%) mention they have an ISO14001 certification. This should indicate an environmental awareness within the company.

In the Netherlands an interesting award scheme "lean and green" was introduced in 2008. This scheme focuses on shippers, transporters (1PL to 4PL) and city councils. Lean and green wants to encourage businesses to grow to a higher level of sustainability. They hold that becoming greener will reduce the environmental impact, while simultaneously saves cost. Since the introduction in 2008 the award scheme has gained popularity and 28 shippers, 59 Logistic Service Providers and 1 City council have joined the award scheme (April 2011). It is expected that this group will increase in time and it has the potential of becoming the leading standard for sustainable transportation in the Netherlands. Members have to write a plan, which contains precise CO_2 targets for 2012/2015 and determine green key performance indicators (website Connekt).

LOGISTIC SERVICE PROVIDERS AND SUSTAINABILITY

The websites of the top 50 companies were not very informative on how the Logistic Service Providers wanted to enhance sustainability. But all participants of the lean and green award scheme have to describe how they want to achieve their goals. The list of tools Logistic Service Providers intend to use include aspects like:

- "Het nieuwe rijden" (new driving style), a training for truck drivers to enhance awareness how driving (gear changing, braking, speed etc.) has an impact on the level of CO_2 production;
- Buying new and less polluting vehicles;
- Reducing energy consumption in warehouses;
- Controlling tire pressure;
- Monitoring driving speed;
- Using more alternative modes of transportation;
- Using more bio fuels;
- Improving loading capacity;
- Buying electric vehicles;
- Increasing efficiency;
- Reducing kilometers driven;
- Avoiding empty hauls
- Etc.

It is not surprising to see that Logistic Service Providers take a variety of approaches to reach sustainability. It is wise to identify and take these aspects which have the greatest impact on sustainability. These are unique to every Logistic Service Provider and its business (Szekely and Knirsch, 2005). So solutions for this aspect may also be expected to depend on the actual situation.

In order to get a better grasp on all these aspects, four categories were created:

Internal approach	-	Aspects which can be organized by the Logistic Service Provider himself.
External approach	-	Aspects which need cooperation with others outside the own organization (e.g. shippers, governments, competitors, stakeholders etc.).
Innovating	-	Aspects previously unknown to the Logistic Service Provider.
Optimizing	-	The Logistic Service Provider aims at improving and achieving better results.

With these four categories a two-by-two matrix can be constructed with the approach (internal or external) on the Y-axis and the X-axis whether the knowledge and skills already exist for improving the present situation (optimizing) or not (innovating). After categorising the approaches mentioned by the Logistic Service Providers in the lean and green award scheme the result as shown in figure 1 was achieved:

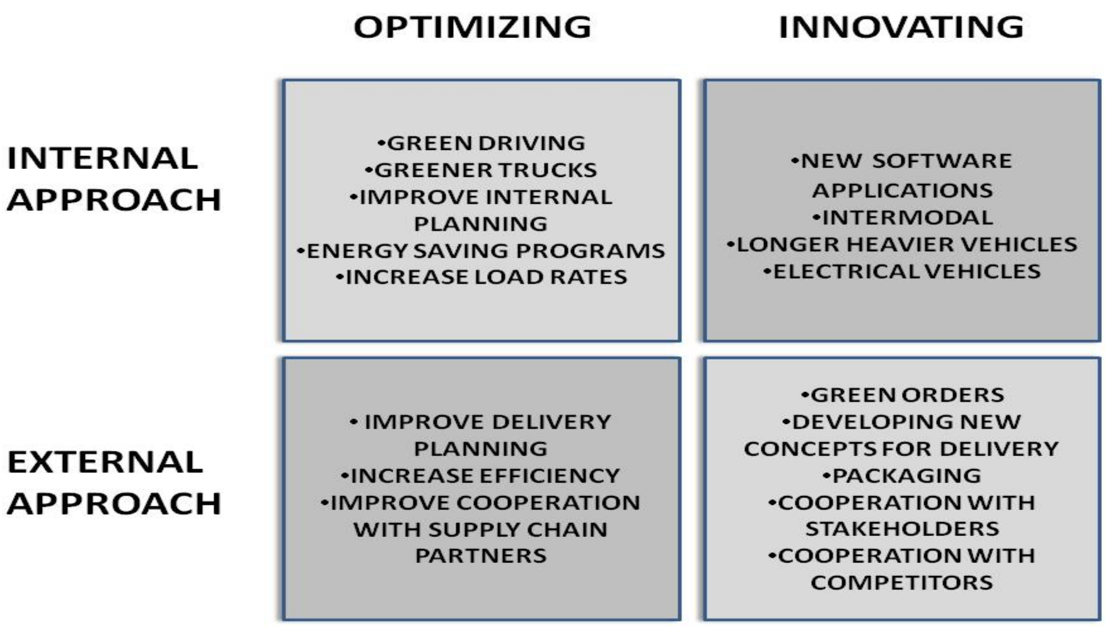


Figure 8 Sustainability activity matrix

This model could be made three dimensional by including an extra level with the aspects Structural and Incidental.

Structural	-	The chosen method will be used for a long time and could be used for any situation.
Incidental	-	The chosen method will be used just once.

This additional level could give a better insight into the question whether the Logistic Service Provider can use the experiences gained to improve other (similar) situations at a later date. It is our intention to interview the participants of the lean and green award scheme for the purpose of understanding where long term/multi applicable measures will differ from short time/one time measures.

When studying the intentions of the 60 Logistic Service Providers participating in the lean and green award scheme, it was found that most measures for improvement are sought within the own company. For example 58 (97%) participators use measures of an internal optimizing character and 29 (48%) mention measures of an internal innovative character. External measures are less popular. 22 (38%) intend to improve efficiency in cooperation programs. 8 (13%) Logistic Service Providers mention cooperation with shippers. These programs include ideas like:

- Awareness programs like informing shippers of the CO_2 footprint of their shipments;
- Discussing delivery time schedules;
- Bundling deliveries to avoid empty hauls.

14 (23%) Logistic Service Providers mention cooperation with other Logistic Service Providers by sharing delivery routes. 5 (8%) Logistic Service Providers mention separate programs for both shippers and competitors. No further details are given.

The remaining 5 (8%) Logistic Service Providers take the whole value chain into perspective. They specifically mention that they want to include all partners in the value chain in their new programs.

It can be concluded that most companies hope to find improvement inside their own company and seem less willing to include partners. Logistic Service Providers also seem to be reluctant to turn to fellow Logistic Service Providers for cooperation. Perhaps cooperation with fellow Logistic Service Providers is not always easy. For instance, a project in Leiden (the Netherlands) to build a central warehouse for city distribution failed due to the unwillingness of the Logistic Service Providers involved to work with competitors (Quak, 2008).

This reluctance for cooperation with shippers is also shown by the web survey. Here 23 (56%) of the respondents state that shippers will not make any concessions if this includes changing the time schedule of deliveries or the use of alternative modes of transportation. According to 31 (76%) of the respondents, the shipper will not make any concession on delivery speed. Apparently, Logistic Service Providers feel that sustainability on its own merit is not a decisive factor for shippers to choose for a specific Logistic Service Provider. The main selection criteria for shippers of transport services are definitely price and reliability. This could indicate that Logistics Service Providers have to come up with new ideas of how to make transportation more sustainable if they want to keep the interest of shippers.

The web survey also provides an interesting view on the ideas of cooperation amongst Logistic Service Providers. Asked if they would be willing to share rides with competitors, 27 (66%) of the respondents answered yes. A smaller group of 18 participants (44%) thinks that their competitors will be willing to cooperate with them. These figures could indicate that there is potential for cooperation between competitors in the transport sector. When split up into the function of the respondent, a difference between these two groups becomes apparent: 13 of the 14 general managers (93%) say they are willing to combine rides with competitors against 6 of the 14 (43%) respondents working on an operational level. Asked if competitors would be willing to cooperate with them to improve sustainability, 8 of the 14 general managers (57%) say yes as opposed to 4 of the 14 (29%) respondents working on an operational level. Apparently top management has a more positive view on cooperation with competitors than those working on an operational level.

CASE STUDY FRUIT CONCENTRATES

Next to reducing the number of kilometers driven or measures taken to reduce CO_2 while driving with less polluting engines, not one Logistic Service Provider mentions considering a change in the way shipments are packaged. It will involve close cooperation between all stages in the supply chain. This however could be an interesting field for both Logistic Service Provider and shipper as has been shown in a recent study on the ecological impact of transporting juice concentrates from Asia to Amsterdam (Dagran, 2011). This study compared the energy intake and carbon foot print of transporting fruit concentrates in the traditional steel drums with the newly introduced flexitanks. Instead of storing 80 drums per container with a total capacity of 21 tons, now one plastic flexitank is used with a capacity of 23.5 tons. This has increased container capacity by 11% and consequently reduced the number of containers shipped by 9%. Another advantage of using flexitanks is that juice transported in these tanks can be stored by minus -6 °C instead of -18 °C for transportation in drums, saving an additional 6% CO_2.

This could have proven the case for using flexitanks instead of steel drums from an ecological point of view. The outcome of the study was expected by the shipper. He simply wanted to know how much the difference in CO_2 reduction actually was. But how much is the impact on the environment of the packaging material used? Perhaps the steel drums can be reused over and over again, while the flexitank can only be used once and has to be scrapped. In this case the CO_2 reduction gained during transportation and storage could be lost on making and recycling the packaging material.

To understand the CO_2 impact of all stages of transporting, freezing and storing the juice concentrates, but also of making, cleaning and recycling the packaging materials Life Cycle Assessment (LCA) was used (Baumann and Tillman; 2004). Every aspect was mapped and measured on energy aspects. The result of this LCA showed that using steel drums will cost 20,000 times more CO_2 than flexitanks! This was not just due to the transportation, but was mainly caused by the huge difference of making, cleaning and recycling steel drums compared to the plastic flexitanks. This outcome was not expected by the shipper, who had expected to find the main CO_2 reduction on transportation and storage, not on matters related to the packaging itself.

This case shows that instruments like LCA can help both shippers and Logistic Service Providers to uncover potential savings of energy and CO_2 by taking in the whole value chain instead of just concentrating on the transport aspect of the company itself. By using the combined knowledge and experience of the various links in the supply chain, innovations are more easily found and could help to enhance the reduction of CO_2 production for the whole supply chain.

CONCLUSIONS

Sustainability has definitely become an integral part of the mission and vision of the leading Dutch transport sector. But shippers do not treat sustainability on an equal footing as classic aspects like reliability and price. These two aspects still dominate the choice for a particular Logistic Service Provider.

Trying to search for ways of improving sustainability, (Dutch) Logistic Service Providers look primarily for schemes which increase efficiency of existing (internal) programs and therefore having the potential of lowering costs. Schemes which include outsiders are less popular, but there is a willingness for cooperation with fellow Logistic Service Providers in order to reduce kilometers transported by combining hauls. Logistic Service Providers seem reluctantly willing to include customers in environmental programs, but the main underlying goal remains improving efficiency. None of these actions are tested on actual fulfillment, therefore further research is needed to investigate what the real actions of Logistic Service Providers are to promote sustainability and how these actions relate to Service Level Agreements and relationships with customers.

REFERENCES

Baumann, H. and A. M. Tillman (2004), The Hitch Hiker's Guide to LCA, An orientation in life cycle assessment methodology and application, Studentlitteratur, Lund, Sweden

Christopher, M., (2005) Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Services Prentice Hall 3rd ed.

Dargan, A.E. (2011), Environmental impact analysis in apple and pineapple juices concentrates supply chains, MSc Thesis Management Studies, Wageningen University the Netherlands.

Dijkhuizen, B. (2011), "Poster met Top 50 LDV-ers is online" dd 12 april 2010 www.logistiek.nl (assessed April 20th, 2011)

Dorp, B. van, A.P.M. Kempe, en H.R. Commandeur (1992), Strategisch marketingmanagement in de transportsector, Deventer, Kluwer Bedrijfswetenschappen.

Francke, J., J.A. Annema and P. Wouters (2009), Zuinig met goed op weg: beleid voor efficiencyverbetering in het goederenwegvervoer, Kennisinstituut voor Mobiliteitsbeleid, Ministry of Infrastructure and the Environment, The Hague.
Goor, A.R. en W. Ploos van Amstel (2009) Distributie logistiek: werken vanuit ketenperspectief, 3de druk Noordhoff Uitgevers, Groningen.
Jeon, C.M. and A. Amekudzi (2005). Addressing Sustainability in Transportation Systems: Definitions, Indicators and Metrics. ASCE Journal of Infrastructure Systems, Vol. 11, No. 10, March 2005.
Kraljic, P. (1983), "Purchasing must become supply management", Harvard Business Review, p 109-117
Maloni, M. J. and M. E Brown (2006), "Corporate Social Responsibility in the Supply Chain: An Application in the Food Industry", in: Journal of Business Ethics, Vol. 68, No. 1, pp. 35-52
Meulen, S.J. van der en M.R.J. Kindt (2010), Duurzame logistiek: met welke verladerseisen worden logistieke dienstverleners geconfronteerd, ING, Amsterdam
Quak, H.J. (2008), Sustainability of urban Freight Transportation: retail distribution and local regulations in cities, PhD. Erasmus University Rotterdam
Szekely, F. and Knirsch, M., 2005, "Responsible Leadership and Corporate Social Responsibility: Metrics for Sustainable Performance", European Management Journal 23:6, 628-647.
United Nations (1987), The Brundlant Commission, Our Common Future (the World Commission on Environment and Development).
Verweij, K. (2011), "Top-100 ldv-ers 2010: Handle with Care" dd 9 april 2010 www.logistiek.nl (assessed April 20th, 2011)
Visser, L. (2010) Thresholds in Logistics Collaboration Decisions: A Study in the Chemical Industry. BOX Press Uitgeverij, Oisterwijk.

Websites

Connekt: www.duurzamelogistiek.nl (assessed April 20th, 2011)
Environmental Forum: www.environmentawards.net (assessed April 28th, 2011)
ICCA: www.icca-chem.org (assessed April 29th, 2011)

DEVELOPMENT OF A SERIOUS GAME ON INTELLIGENT CARGO FOR AWARENESS RAISING AMONG STUDENTS

Jannicke Baalsrud Hauge[1], Marcus Seifert[1], Janine Selle[2], Stefan Daniel[2]
[1]BIBA – Bremer Institut für Produktion und Logistik GmbH
Hochschulring 20, 28359 Bremen, Germany
e-mail {baa,sf}@biba.uni-bremen.de

[2] Master students at the University of Bremen, Fachbereich 4,
Bibliothekstraße 1, 28359 Bremen, Germany

ABSTRACT

The use of serious games may raise the awareness and understanding for the main problems affecting freight transportation on a global scale. Also how information- and communication-technologies (ICT) might be used in a supply chain as well as the Intelligent Cargo Concept can be simulated in a gaming environment. Through gaming participants can experience the limitations/boundaries of globally operating networks as well as how ICT and upcoming concepts like that of Intelligent Cargo (IC) can help to overcome/reduce these limitations/boundaries.

This paper discusses the design and development of a serious game on Intelligent Cargo in the supply chain. The objective of the game is to increase the awareness and the understanding of the impact implementation of ICT have on own working environment and along the supply chain.

INTRODUCTION

Some of the main problems affecting freight transportation on global logistic processes are based on limited information on the movement of goods. Despite the availability of several technologies on the market, the majority of goods still move without accompanying information in electronic form. This affects the goals of logistical operations like punctuality, accuracy and quality negatively. An upcoming concept supporting the synchronization of information and material flows is to make the cargo item intelligent. This approach combines the downstream and upstream of information across the flow of goods along the supply chain. It imply the use of ICT tools on the cargo, including electronically freight papers, Radio-Frequency Identification Technologies (RFID), interoperability platforms for data interchange, mobile technologies and global positioning systems (Baalsrud Hauge, 2010). This induces a paradigm shift within supply networks which leads to large organizational changes and new requirements in the skills and competencies of involved staff. (Euridice 2009)

Even though the technology is available, it has not penetrated the transport sector yet, and in the case of IC, there is no real experience in operating it except under pilot condition. Consequently, it is difficult for employees to understand the impact of the concept. For such cases, the utilization of experiential learning methods has proven to be very efficient (Windhoff, 2001, Schwesig, 2005). Serious games has a long tradition within military education (Hays, Singer, 1989), but during the last decades, serious games have also been used for explaining the bull whip effect, as well as for the awareness raising of supply chain management.

PROBLEMS AND OBJECTIVES

The challenges of conveying the principles of Intelligent Cargo to students, is that even though the technologies are available, the concept as such has only be prototypical implemented. Thus, it is difficult to make any concrete experience or to analyse available business games. Consequently, it is possible to mediate the underlying technologies, but not to show how the concept affects the performance of the supply chain or the necessary organizational changes.

The utilization of serious games can close the gap between concrete experience and the unavailability of certain technologies.

Experiential learning methods have proven to be very efficient in such cases (Windhoff, 2001 Schwesig, 2005). Chickering and Gamson (1987) say listening is not enough, people must read, write, discuss or be engaged in solving problems in order to learn. The method of experiential learning revealing that learning through experience and reflections is more effective than individual knowledge acquisition.
The learning cycle by Kolb and Fry (1975) describe the way of gathering knowledge through the direct participation on events.

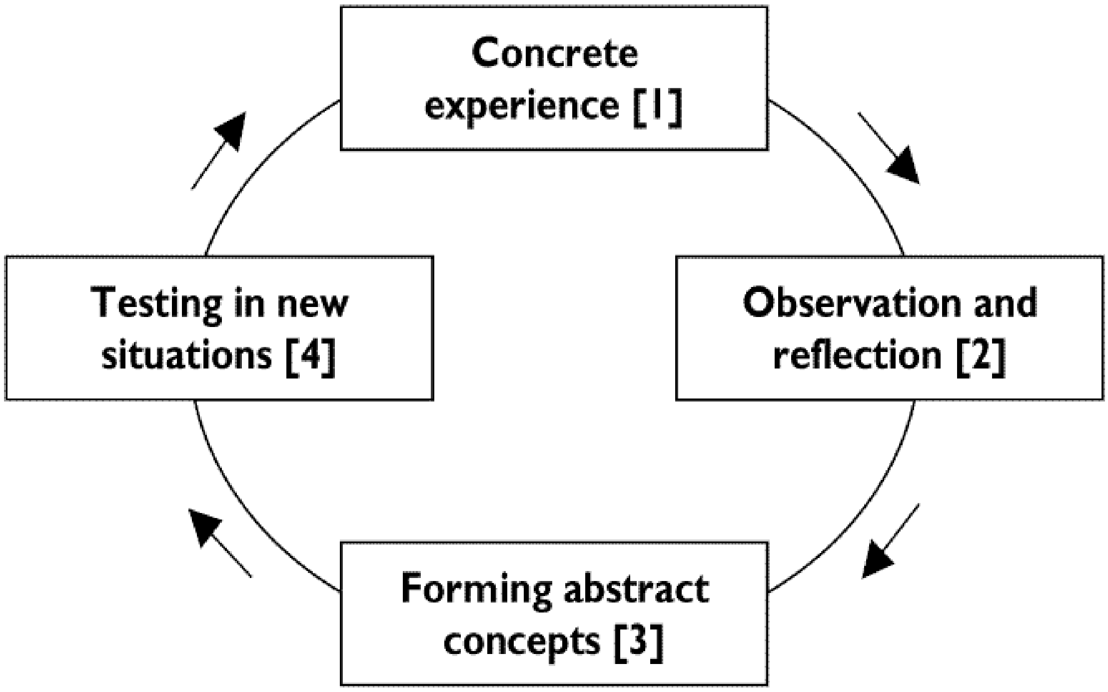


Figure 9: Learning Cycle by Kolb (1984)

They argue that the learning cycle can begin at any of the four points and that it should be approached as a continuous spiral.
In order to be able to emphasize the impact IC has on the supply chain, a game must fulfill the following requirements:

- Should visualize organizational changes coming along with the implementation of Intelligent Cargo and how the working environment of the employees changes.
- Flexible gaming scenarios and handled products. The game and the handled product should be flexible for adopting different scenarios or core point of impacts (e.g. environment-friendliness).
- be adaptive in relation to the participants' skills and needs.
- Focus on how IC can reduce the main problems that exist in managing a supply chain.
- Allow independent decision making.
-

Additional to the objectives of the game a learning concept were designed to mediate methods for reflection. With the given methods the participants are able to reflect the decisions they made and to work out the impacts of Intelligent Cargo which have been experienced in the game.

LEARNING CONCEPT AND SYLLABUS

The learning objectives belong to the categories professional, methodological, social and reflection skills. Professional skills of the game focus on improving knowledge base on supply chain management and Intelligent Cargo. The participants experience the use of Intelligent Cargo in a supply chain and learn to understand the impact implementation of Intelligent Cargo may have both on an own working environment as on the whole supply chain. They get to know the strengths of the Intelligent Cargo concept and its limitation. Social skills are to be motivated, to contribute to discussions, to lead self-confidently discussions and to work together toward common goals.

Reflection skills are the deepened research and the critical analyzing of the contents regarding the impacts of Intelligent Cargo taught.

The target group comprises engineering students at master level. They have only little experience in supply chain management and logistical processes, thus a blended learning concept has been inserted so that needed theoretical topics can be mediated prior to gaming. The concept integrates lecture elements, a serious game as an actively deepening exercise and a workshop.

The "IntelliCa" seminar lasts two days (figure 2). On the first day lectures are about supply chain management, intermodal transport, cross-docking concept, Intelligent Cargo and metaplan-presentation techniques will establish the theoretical basis.

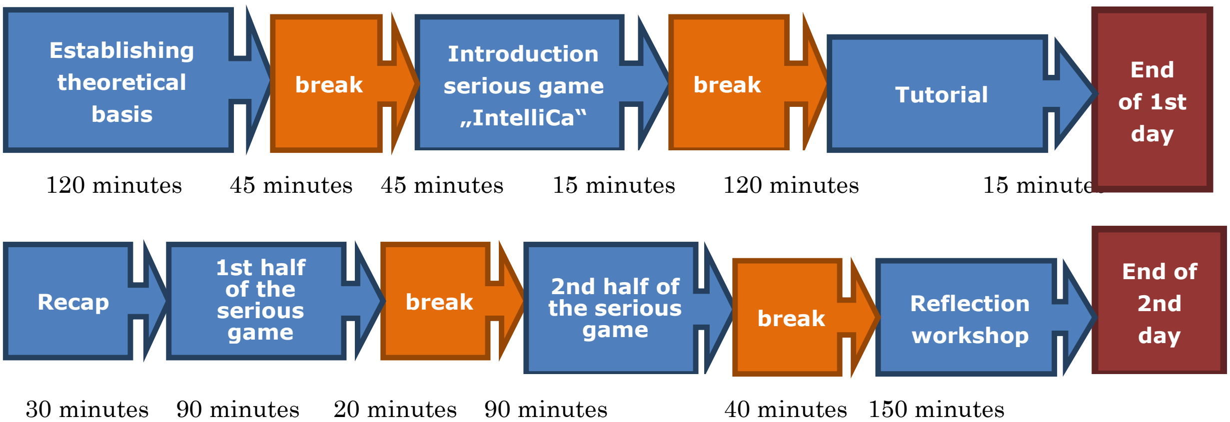


Figure 2: blended learning concept of the IntelliCa seminar

After the theoretical class, there will be a short introduction to the game. At the beginning of the tutorial d**ifferent roles of the game** will be **assigned** to students. They will have time to prepare the task (job) description, to familiarize with the new role, task, workplace, forms and documents and material. After a question and answer session a few rounds of the serious game will be played as tutorial. In this time the students also have the possibility of asking questions. The second day starts with a recap followed by playing the "IntelliCa" game. After this participants should reflect on the game and exchange their experiences. In small groups students will look into a given **subject more** closely. They have to discuss and solve a problem, create a presentation and present their results other groups. Placing participants into smaller **groups** creates more **interaction.**

GAME PLAY:

The serious game "IntelliCa" is a role based game with pre-defined roles. 18 participants play as end product producer, module producer, suppliers or transshipping center in a supply chain. Also the transport of the container between participants and the Intelligent Cargo are simulated by a role. The simulation uses LEGO®-blocks to symbolize end products, modules and parts.

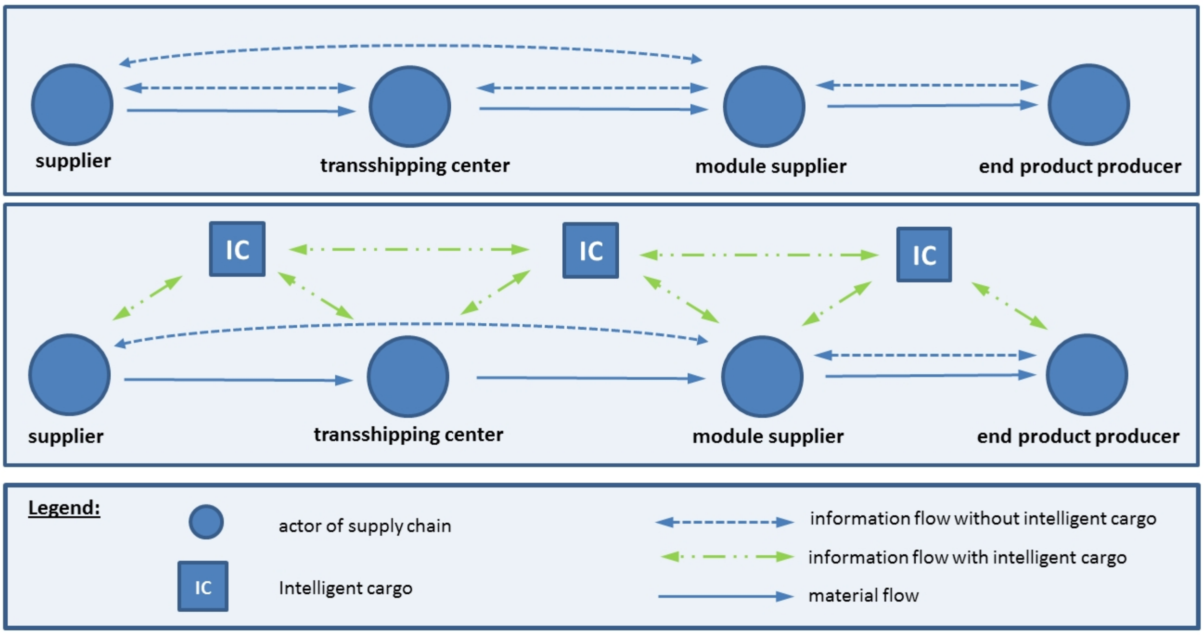


Figure 3: Change of information flow in the game

The goods can be shipped by sea, air, rail or truck. On the way to the consignees goods pass transshipping centers (cross-docking hubs), where incoming goods will be unloaded from containers to combine goods with same destinations.

The game is round based and each participant has time to carry out the given tasks so that orders will be appropriately delivered in terms of schedule and quality. Internal processes of the companies and transshipping centers are abstracted at a high level. Information and content of IT-processes is depicted in forms.

The idea behind the upcoming Intelligent Cargo concept is to make every cargo item intelligent. In the game the Intelligent Cargo system is simulated as a role. Due to the high numbers of intelligent cargo objects, the supply chain is divided into four sections whereby one or two player per Experiential learning methods have proven to be very efficient in such cases (Windhoff, 2001, Schwesig,2005). section simulates the Intelligent Cargo system. The players receive a role description on how to act. Their tasks are for example the inspection of incoming and outgoing good (right parts, right amount), automatic entries in forms, rerouting, tracking and tracing.

Figure 3 shows an excerpt of the information and material flow with and without support of Intelligent Cargo in the game. If the order is processed with the use of intelligent cargo, information between two stakeholders of the supply chain is shared through the intelligent cargo system. Direct communication between the stakeholders is restricted on the order process.

FIRST RESULTS

Different game settings are possible in order to let the students experience the impact of Intelligent Cargo in a supply chain. We have considered two such scenarios. The first is a parallel utilization of classic and Intelligent Cargo in one run of the game or the separations of the game in two consecutively runs, first only with classic cargos the second one with Intelligent Cargos.

First tests with external participants show that the main objective of the serious game, the mediation of the paradigm shift driven by intelligent cargo, was fulfilled by playing the first scenario. The learning outcome by using classic and intelligent cargos parallel was higher: those players having an intelligent cargo system role realized the functionality of the system by accomplishing their task. The actors playing a stakeholder role of the supply chain realized the impact directly by the reduction of tasks to carry out.

The tests also showed an unexpected problem: it was too difficult to complete the different forms on a short time, and thus some roles appeared to be bottle-necks. As counter measures, a tutorial on completing the forms was introduced and the workplace layout for every role was redesigned to simplify the sequence of work in the roles. This seems to work out, the bottlenecks were reduced.
The test of the second scenario showed several disadvantages: the play time extended and esp. the intelligent Cargo roles were idle on the first run whereas the workload of the supply chain actors would decrease enormously on the second run. This resulted in a lack of attention that affected the awareness of the impact negatively.
In order to reduce the problems with completing the forms more, we considered to introduce an ICT tool. The introduction would support the understanding of the used technologies since support RFID, GPS, electronically freight papers or modern communication tools is a part of the concept. This could be done without too many changes in the game, but it is not possible at the moment to implement cargo intelligence in such away, that it appears clear to the students. However, the introduction of ICT will lead to a need for a tutorial before hand and also the handling during the game might lead to less attention on the learning objectives. The advantage of simulating the Intelligent Cargo with all ICT tools included is to increase the understanding of how the tools work. Especially if the game addresses students with only basic logistical knowledge the usage of such tools will be counterproductive. The game concentrates on mediating logistical operations in a supply chain with the essential forms and the classic simplified information flow. Consequently, this option will be looked at in more detail after some more testing.

ADAPTIVITY OF THE GAMING SCENARIO

It is important for the players that the gaming scenario does have similarities with their own working environment or can show different supply chain. Consequently, the gaming concept is general and can be adapted to fit other supply chain scenarios, too. In order to keep the gaming scenario as flexible as possible, the following actions have been undertaken:

- The product is simple and is symbolized with Lego®-blocks. Thus sometimes the Lego blocks are parts of a car in an automotive supply chain or sometimes it is deep-frozen goods past through a food supply chain.
- Number of stakeholders' roles and locations are flexible. Transport routes could be extended or shorten.
- Transport routes could be adapted to realistic routes.
- And the mode of transportation could be customized too.

The focus of the game is the illustration of the impacts of Intelligent Cargo and the importance of synchronous material and information flow. Depending of the target group further objectives are possible:

- Ecological aspect: The game can be adapted to illustrate how intelligent cargo increases the efficiency of the intermodal transport. It shows how the combination of the transport modes could be improved or how a higher load factor will be reached, which induces a lower environmental load.
- Work environmental aspect: The game shows how the implementation of intelligent cargo affects the work environment of the participated organizations and the organizational changes.
- Technical aspect: Another objective could be the handling of implemented ICT-tools and which impacts, especially technical changes, it may have both on own work environments and on the whole supply chain.

NEXT STEPS

The game is still in its testing phase, but based on the first results, we will look at how ICT can be implemented without drawing the attention of the players on the IC concept towards handling of the tools. In a first step, it will be discussed if the following elements of the game could be substitute by technical components or tools:

- Freight documentation: The freight documents can be substitute by RFID tags attached on the cargos. A reader on every location would be necessary to read the information memorised on the tag.
- Tracking and tracing: A multi-touch desk can display the location of each cargo. But limited information of the location is necessary hence not every role has access to all information.
- Locating: With the aid of specific software the cargos can be located by their signal strength (if mounted with RFID tags) and displayed on the multi-touch desk or combined with a flash application on a classic monitor.

Also the implementation of technical components would not change the blended learning concept much. It requires only a modified tutorial where the handling of the system will be mediated and not the filling in forms.

CONCLUSION

This paper discusses the design and development of a blended learning concept and a serious game on intelligent cargo in the supply chain. First test show that the gaming concept enables to increase participants' understanding of the Intelligent Cargo concept. They learned how ICT impact the processes in the supply chain, which benefits the stakeholder have and what the strengths and the limitation of the concept are. The work has been carried out as a one year project students of the University of Bremen. The testing will continue in next semester and a new master course will look at the result and impose changes.

REFERENCES

Chickering, A, W. and Gamson, Z, F. (1987) Seven Principles for Good Practice. *AAHE Bulletin* 39: 3-7. ED 282 491. 6 pp. MF-01; PC-01.

EURIDICE Project White Paper (2009) Version November 2009, available: www.euridice-project.eu .

Baalsrud Hauge, J. and Seifert, M. and Thoben, K-D. (2010) The potential of serious games for supporting the implementation of the intelligent cargo concept in supply networks, University Nottingham Business School, In: Pawar, K.S., Lalwani, C.S.: Proceedings of the 15th International Symposium on Logistics: Configuring Next Generations Supply Chains, University Nottingham Business School, Nottingham, UK

Hays, R. T.; Singer, M. J.(1989): Simulation fidelity in training system design: bridging the gap between reality and training. New York.

Kolb, D. (1984): Experiential Learning - Experience as the Source of Learning and Development. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Kolb. D. A. and Fry, R. (1975): Toward an applied theory of experiential learning in C. Cooper (ed.) Theories of Group Process, London: John Wiley

Schwesig, M. (2005) Development of a web based management simulation of knowledge exchange in networked manufacturing organizations. BIBA Reihe Band 54, Mainz Verlag, Aachen.

Windhoff, G. (2001) Planspiele für die verteilte Produktion. Entwicklung und Einsatz von Trainingsmodulen für das aktive Erleben charakteristischer Arbeitssituationen in arbeitsteiligen, verteilten Produktionssystemen auf Basis der Planspielmethodik. Dissertation at the University of Bremen.

A MONITORING SYSTEM FOR DANGEROUS GOODS (DG) FOR AIR CARGO TERMINAL

*Minkyung Kim, Yoon Seok Chang**

School of Air Transport, Transportation and Logistics,
Korea Aerospace University, Republic of Korea
czel13@gmail.com , yoonchang@kau.ac.kr
*Corresponding Author

1. INTRODUCTION

Recently, importance of logistics has been emphasized to strengthen the competitiveness of each company. Due to the increasing demand for world trade, the traffic of high value-added products has been increased as well. Since the characteristics of the goods trade among countries, the demand for air transportation has been rising. According to International Civil Aviation Organization (ICAO) and the aircraft manufacturers such as Boeing, the demand for air transportation will be increased as much as three times in 20 years to come (Boeing, 2010).

Despite the increasing amount of air cargo, cargo handling based on systematic management system is yet to be organized for air cargo terminals in Korea. It means that many of process are doing manually in air cargo terminal. Even though some systematic management systems have been applied to the air cargo terminal partially, information generated from the cargo is not integrated and the real-time monitoring for cargo is not realized. Generally, the freight charge for special cargo such as perishable and dangerous goods is higher than general air cargo and perishable and dangerous goods need more careful handling owing to its possibility of contamination and accident.

This research has reviewed dangerous goods (DG) area of air cargo terminals in Korea and Europe to develop better management system for dangerous goods. The goal of this research is to improve DG area management using methodical system.

2. REGULATIONS FOR AIR DG MANAGEMENT

DG cargo in Korea is currently managed by a couple of regulations established by International Aviation Transportation Association (IATA), Ministry of Land, Transport and Maritime Affairs and airline. However, Dangerous Goods Regulations (DGR) by IATA is broadly used as the international regulation and includes the others. Special cargo which is perishable cargo, live animal, dangerous goods and so on had been prohibited to transport goods by air at the beginning of air transportation, but IATA had established regulations for special cargo which allows transportation of special cargo by aircraft. DG is divided into 9 classes by characteristic of chemistry in DGR (IATA, 2010). Some of Classes have more detailed divisions. Each class has separate rules for labelling, handling, packing and so on. The number and name of DG classes are as below.

Class No.	Class Name
1	Explosives
2	Gases
3	Flammable Liquids
4	Flammable Solids
5	Oxidizing Substances and Organic Peroxides
6	Toxic and Infectious Substances
7	Radioactive Material
8	Corrosives
9	Miscellaneous Dangerous Goods

Table 1. Classes of Dangerous Goods (IATA DGR, 2009)

3. DG MANAGEMENT IN AIR CARGO TERMINALS

We have conducted field surveys of air cargo terminal and interviewed people concerned. Based on the result of survey, we have designed new process which could improve existing process by adopting Dangerous Goods Management System (DGMS).

3.1 DG PROCESS OF A AIRLINE

Air cargo terminal of A airline in Korea is using a fence with a lock to isolate DG from general cargo and people. DG area is managed by a security guard and has no designated storage place for each DG class. In case of accident, a finder should notify to the related workers and departments. DG handling process and accident handling process of A airline is as in Figure 1.

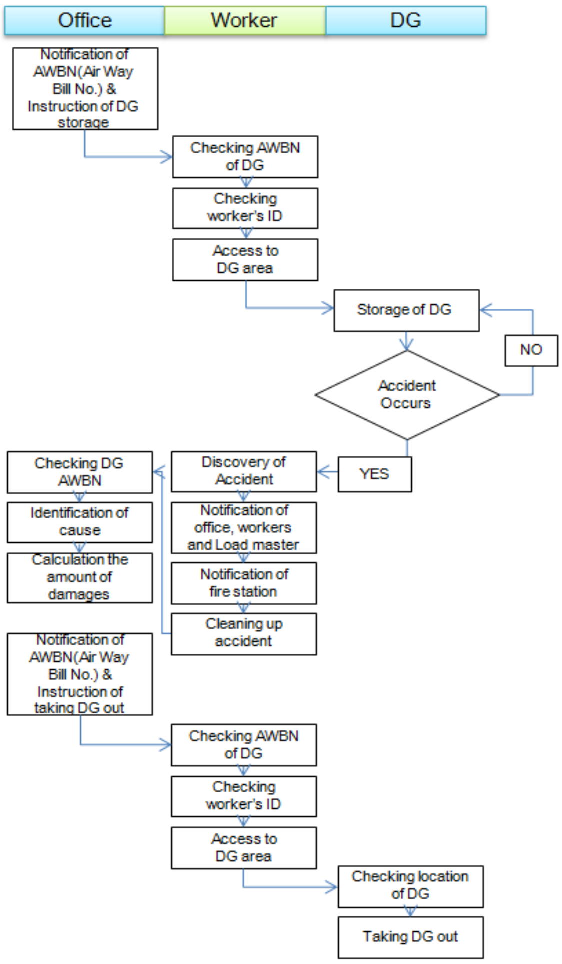


Figure 10. DG storage and accident handling process of A airline

3.2 DG PROCESS OF B AIRLINE

Air cargo terminal of B airline in Korea has DG area managers who are working 24 hours a day. In this airline, DG area is divided into 9 districts by classes of DG and separated by fence, but there is no restriction to access the DG area. DG storage and accident handling process of B airline is as below.

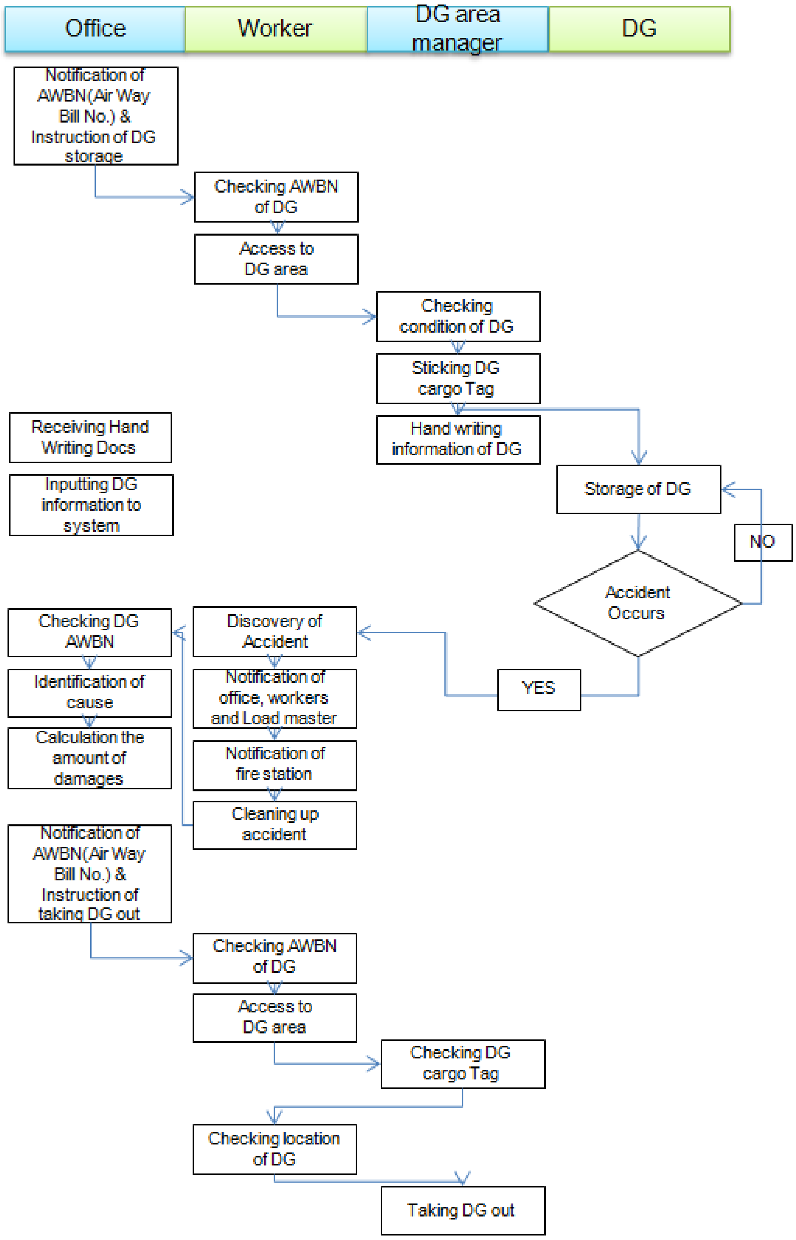


Figure 2. DG storage and accident handling process of B airline

When the accident occurs, DG area manager and workers should notify to load master and to the office by cellular phone or two-way radio.

3.3 COMPARISON BETWEEN AIRLINES

Airlines in Korea do not have separated (or fenced) DG cargo area but the companies have designated area only for DG in the air cargo terminal. Table 2 shows the comparison of airline A and B.

Airline	A airline	B airline
DG area manager	X	O
Separated storage area by DG class	X	O
Alarm facilities	X	X
Monitoring means	Person	Person
Restricted access for no-license holder	X	X
recording DG information	X	O Handwriting and dual working

Table 2. Comparison of A and B airline

A airline has no DG area manager and separated storage area by DG class. Workers in both airlines are monitoring DG area and there is no control for no-license holder. B airline has DG area manager, and they have separated storage by DG class and collecting DG information. They should input information twice for each DG (e.g. handwriting and computer).

3.4 ISSUES OF CURRENT DG MANAGEMENT SYSTEM

After interviewing and conducting research for the each airline company, we found out problems of DG management system. According to comparison between A and B airlines presented in Table 2, B airline is doing more systematic management of DG than A airline. The Figure 3 is detailed process for DG area management of B airline.

The most important issue of DG management process is availability of DGR. Every airline should follows IATA regulation, the international standard regulation for air DG, however, current practice suffers from the following manual process: it is difficult to write DG cargo tag and hard to search information from manual book (i.e. IATA manual is over 1000pages); it is inefficient to notify some event by cell phone and two way radio currently used (e.g. It takes much time to alert accident to workers, load master and the office). Delayed notification could cause huge costs and damages for human, cargo and environment. In both airlines there are no alarming facilities such as siren or real time messaging, so workers are hardly recognized accident information.

There is a rule for isolation among DG classes which might influence on each other. In case of B airline, they divided 9 places according to the rule but, it is difficult to detect a cargo when it is placed in wrong area. Many of advanced air cargo terminals such as G1XL in CDG airport and Schiphol airport have introduced rack with barcode to manage its location information.

Lastly, DGR recommends that DG must be handled by qualified people who completed required education in approved educational facilities by IATA. In spite of this rule, access to DG area is free to every worker many times. Even though there is an access control, it is only for checking identity of person. In Schiphol airport and G1XL, every ID card has different authorities to access specific place such as general, perishable, dangerous goods terminal and airside.

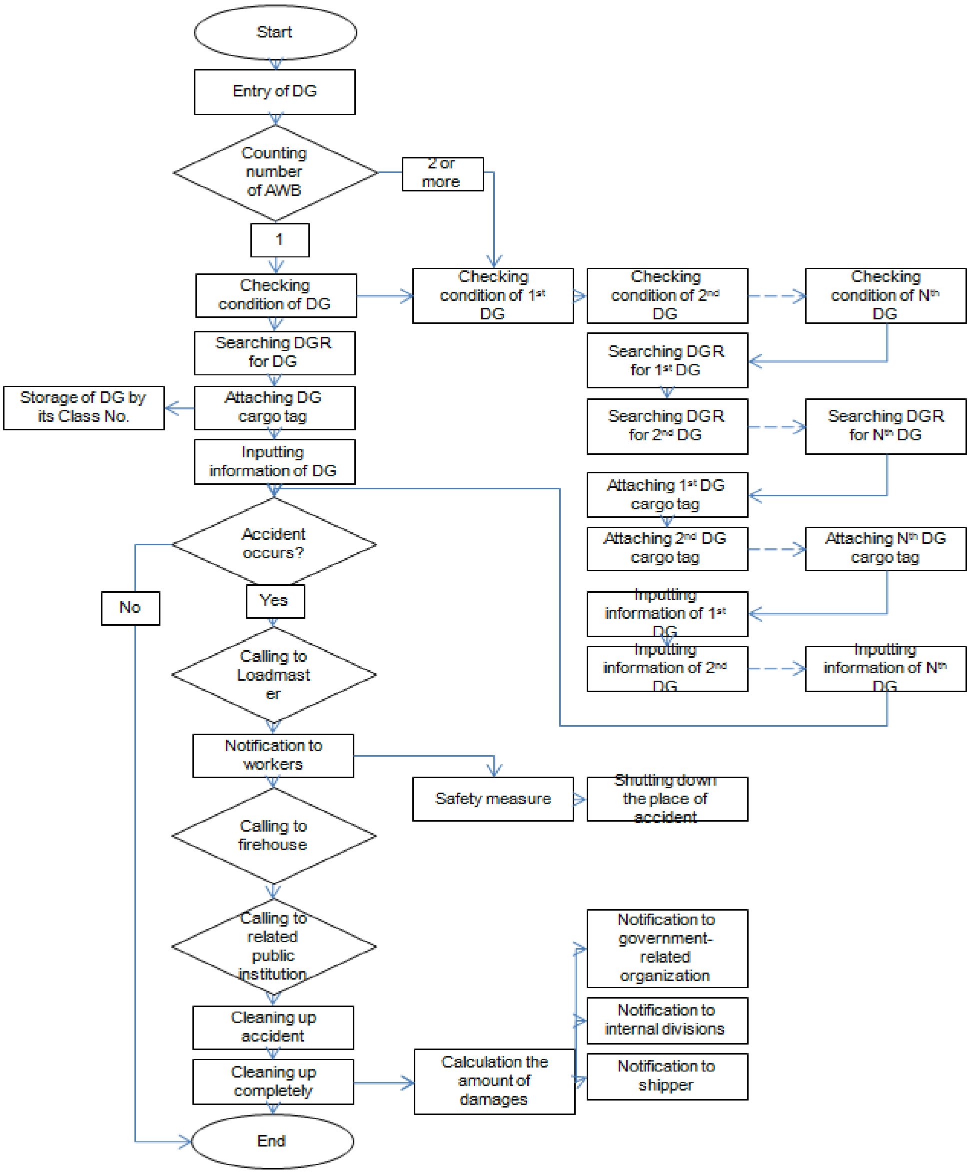


Figure 3. Detailed process of B airline

In Table 3 we summarized issues addressed.

Division	Problem
Process	To use DGR for searching information of DG is difficult.
	Accident detection is totally dependent on naked eye of workers.
	Accident notification by cell phone and two way radio might lead delay to clean up.
DG storage and handling	It is hard to find the stored location of DG and whether against the separate rule or not.
	To establish the cause of accident is impossible.
Access to DG area	No restriction of accessing to DG area
Other	DG cargo tag is written by hand.
	Dual working for writing DG information by DG manager.

Table 3. Issues in DG area of air cargo terminal

4. NEW METHODS FOR DG MANAGEMENT IN AIR CARGO TERMINAL

4.1 SYSTEM FOR IMPROVEMENT

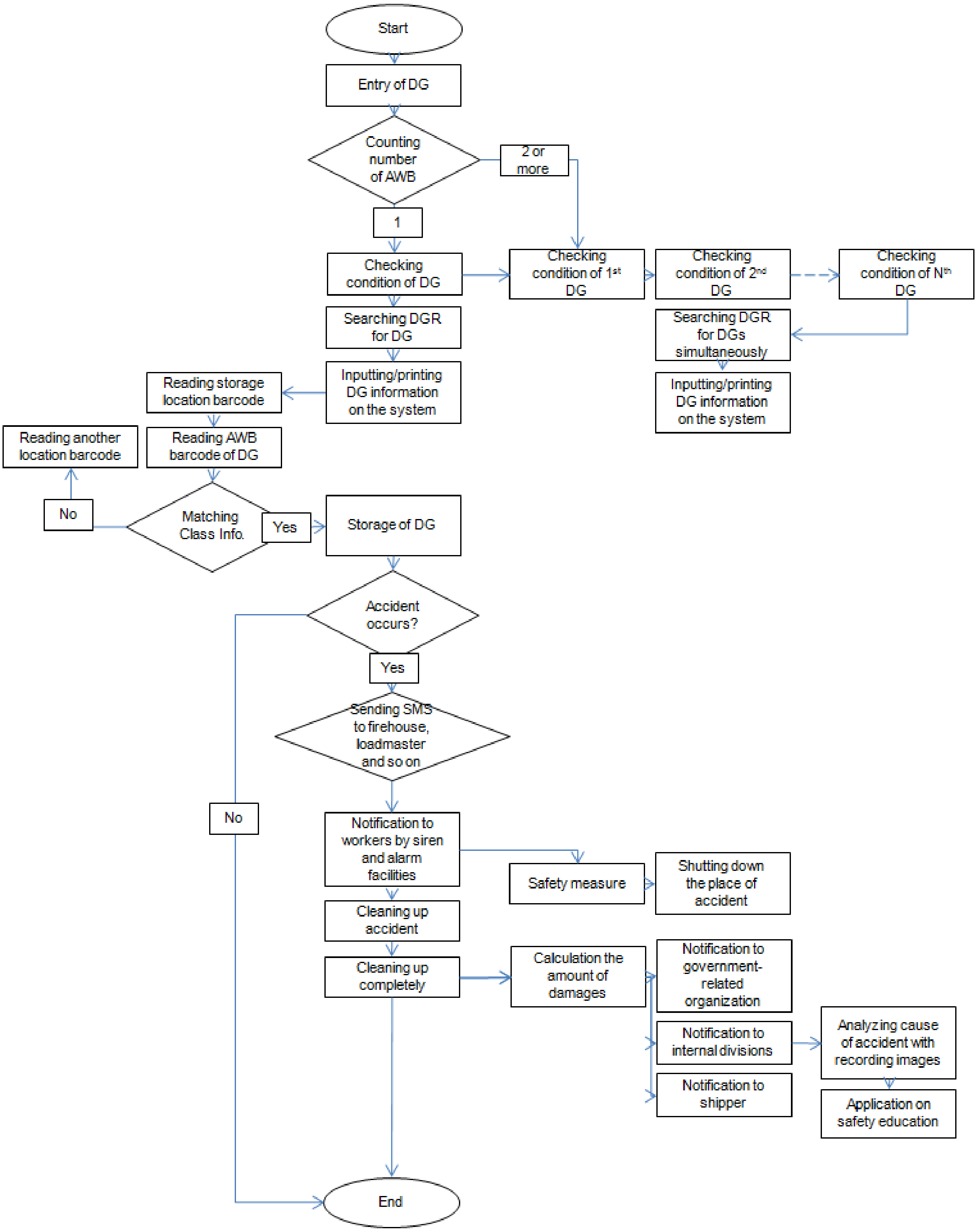


Figure 4. Improved process for analyzing effect of developing systems

We developed 4 systems for improving current problems. The systems are Master Data Management (MDM) system, matching system between location and DG class, access management system and monitoring system which is checking for DG handling. We have analyzed its potential improvement using Extend 6.0, the simulation tool. Figure 4 is the workflow for those suggested systems. We have listed potential improvement that the new procedure can bring to current DG management as in Table 4.

Division	Improvement method
Process	Development of MDM system for searching DGR easily.
	Detecting work status in DG area by Monitoring module.
	Sending SMS to loadmaster and DG manager when the accident occurs.
DG storage and handling	Matching information between storage location and DG information automatically by barcode.
	Recording working scene in DG area with camera to find cause of accident and responsibility.
Access to DG area	Restricted access to DG area using ID card (e.g. barcode or RFID).
Others	Writing and Printing DG cargo tag using tablet PC such as iPad or Galaxy Tab.
	Deleting the dual working by inputting system directly when DG cargo tag is written.

Table 4. Improvement methods for current problems

4.2 RESULT OF SIMULATION

For the verification of new methods, we have measured: the entire process time, compensation for accident, work burden of DG manager and storage waiting length and time for entering DG area. The result of simulation is as in Table 5.

Measuring elements		Before applying systems (a)	After applying systems (b)	Percentage of Improvement
Entire process time		30.96min	15.67min	49%
Compensation for accident *SDR : Special Drawing Rate		35,294.4SDR*	17,859SDR	49%
Work burden of DG manager		98.47%	42.42%	57%
Storage waiting Length for entering DG area	Average	3.77item	0.13item	97%
	Maximum	10.34item	2.9item	72%
Storage waiting Time for entering DG area	Average	26.25min	0.92min	97%
	Maximum	70.24min	10.96min	84%

Table 5. Result of simulation

By applying DG area management systems, speed of searching DG information from DGR could be improved and it could also bring paperless working condition. Also alarming system such as sending SMS could reduce the time for clean up accident. Existing work burden of DG manager is almost impracticable because it reached 98.47%. However, the adoption of systemized writing and printing DG cargo tag, could reduce work burden to 42.42%. The new method also improved storage waiting length and time for entering DG area simultaneously.

5. CONCLUSION

There are many studies on DG for marine and road transportation compared to the study for air transportation. In some countries, air cargo terminal have dedicated DG terminal, but national air cargo terminal in Korea have a conventional DG terminal which requires systematic DG management.

To understand the needs of airport, airlines and government, we have conducted several field surveys and interviewed loadmasters working in air cargo terminal. We analyzed the process of DG management inside DG area to find current issues. Based on current issues, we suggested the improvement methods for each issue. It is considered that the suggested DG management methods enables systematic DG management while improving safety and bringing economic efficiency as presented by simulation results.

6. ACKNOWLEDGEMENT

This research was supported by a grant (36-2007-C-Airport) from Development for the Intelligent Airport System Program funded by Ministry of Land, Transport and Maritime Affairs of Korean government.

REFERENCES:

Boeing (2010) "World Air Cargo Forecast 2010-2011"

Chang, Y. Yeh, C. Liu, Y. (2006) "Prioritizing management issues of moving dangerous goods by air transport" Journal of Air Transport Management, Vol.12, No.4, pp.191-196.

Chang, Y. S. Son, M. G. Oh, C. H. (2011) "Design and implementation of RFID based air-cargo monitoring system", Advanced Engineering Informatics, Vol.25, No.1, pp.41-52.
ExtendSim, http://www.extendsim.com/

Fabiano, B. Currò, F. et al. (2002) "A framework for risk assessment and decision-making strategies in dangerous good transportation", Journal of hazardous materials, Vol.93, No.1, pp.1-15.

IATA (2010) Dangerous Goods Regulations.
IATA (2009) IATA e-freight Special Cargo.

Kubíček, Rndr P. Brázdilová, Rndr J. (2007) "Transport of Dangerous Chemical Substances and its Cartographic Visualisation Authors:", Military Technology, pp.1-4.

Planas, E. Pastor, E. et al. (2009) "Results of the MITRA project: monitoring and intervention for the transportation of dangerous goods", Journal of hazardous materials, Vol.152, No.2, pp.516-526.

Rømer, H. (1995) "Accidents during marine transport of dangerous goods. Distribution of fatalities", Journal of Loss Prevention in the Process Industries, Vol.8. No.1, pp.29-34.

Ruizgarcia, L. Barreiro, P. Robla, J. (2009) "Performance of ZigBee-Based wireless sensor nodes for real-time monitoring of fruit logistics", Journal of Food Engineering, Vol 87, No.3, pp.405-415.

Samuel, C. Keren, N. Shelley, M.C. Freeman, Steven A. (2009) "Frequency analysis of hazardous material transportation incidents as a function of distance from origin to incident location", Journal of Loss Prevention in the Process Industries, Vol.22, No.6, pp.783-790.
Valente, Fabio, Zacheo, Giammarco. et al. (2009) "A telecommunications framework for real-time monitoring of dangerous goods transport", 2009 9th International Conference on Intelligent Transport Systems Telecommunications(ITST), pp.13-18.

Yang, J. L. Fengying. et al. (2010) "A survey on hazardous materials accidents during road transport in China from 2000 to 2008"., Journal of hazardous materials, Vol.184, No.1-3, pp.647-653.

VALUE STREAM MAPPING IN THE AIR TRANSPORT INDUSTRY
- A CASE OF AIR FRANCE

Violeta Roso, Kent Lumsden, Antoine Clement and Muriel Vlody*
Division of Logistics and Transportation, Chalmers University of Technology, 412 96 Göteborg, Sweden * +46 31 772 1338, violeta.roso@chalmers.se

ABSTRACT

Purpose:
The companies in the air transport industry, in order to retain customers, have to deliver high service at low costs. The cost cutting opportunities rely mostly on the ground operations, in the backstage activities. The purpose of this study is to provide an audit of the analysis of Value Stream Mapping of Air France logistics flows regarding the linen on-board supply.

Research approach:
The study is conducted jointly with the Air France subsidiaries Servair and ACNA whose members formed a team to perform the Value Stream Mapping process. The aim was to provide a set of recommendations regarding possible improvements in the way of conducting the VSM at the company.

Findings and Originality:
The audit outlined several aspects regarding the way the study was conducted, and resulted in a set of recommendations in order to improve the outcomes from this VSM study. A thorough reflection on the whole process should have been made in order to be aware of the method's limits and take them into account. Furthermore, the importance of the communication between all the actors should have been emphasized so that the work could have been done efficiently.

Research impact:
The VSM cannot be adapted easily to the air transport industry that is strongly relying on human factors, which are not considered by the VSM technique.

Practical impact:
Although the suggested recommendations could be applicable and useful one should keep in mind that the air transport sector is subject to strong regulations that impede straight changes.

Keywords:
Value Stream Mapping, Air Transport, Ground Operations, Air France

INTRODUCTION

In order to gain or retain competitiveness, the air transport industry has to have good understanding of customers' needs and has to know how to satisfy them (HANLON, 1999). Some examples "know how" are in-flight entertainment services, tailored check-in service according to the travel class, efficient baggage follow-up and delivery, or seating comfort (including provided accessories). The on-board service is the most visible way to increase this customer's satisfaction, but the same is not possible without efficient ground operations, including external and internal logistics. One way of controlling those ground operations and of finding possibilities for improvements is by conducting internal audits and benchmarking. However, the air transport area is a strongly regulated area, and often happens that simple solutions cannot be applied due to noncompliance with the regulations, especially the safety aspects that apply on an airport.

At Air France, weaknesses have been identified in the linen supply process, by both on-site analyses and accountability checking. The on-site analyses showed high inventory levels and outlined the flows' complexity that people had difficulties to fully understand,

and the accountability checking showed high costs regarding linen items processing. This linen supply process includes three categories of actors – the laundries who clean up the linen, the catering centres who load and unload the aircrafts, and the aircrafts themselves, represented by Air France.

Due to the complexity of the different flows, and the lack of visibility on the inter-actors flows, Air France created a computerized controlling tool for linen items as well as conducted a value stream mapping analysis (VSM) of all the linen logistics flows. Therefore the purpose of this study is to provide an audit of the VSM analysis of Air France logistics flows regarding some of the articles that compose an aircraft's fitting out. In other words this study intends to analyse the way of applying the VSM process by Air France and its subsidiaries. The aim is to provide a set of recommendations regarding possible improvements in the way of conducting the VSM.

METHOD

According to Von Roessing (2002), an audit may take different aspects, usually within the framework of a review or of a preliminary activity to a consultancy assignment. Those aspects may be from an internal as well as from an external viewpoint, and focus on every activity in a given company, from finances to workshop operations. An internal audit, meaning a self-audit, depends on bureaucratic procedures and can as well be used for external audits, meaning verifications made by an independent organization (Power, 1994). Furthermore the authors suggest the audit report should contain a presentation of the audited system, the objectives and scope of the audit, a presentation of the fieldwork, and the auditor's opinion on the results.

The study started with a familiarization with Air France as a company, its flows from the arrival and unloading of a plane, until the plane is reloaded and ready to take off. The data collection was very similar to the process of familiarization, but couldn't be conducted at the same time since it required a full understanding of the processes. The first step was an analysis of the whole system with a data collection through the available documentation and written procedures; which was supported by observations and interviews on the site. The on-site observations and interviews were carried out during the peak hour flight schedules and the interviewees were both, from the management level and from the operational level, in order to get different perspectives on the subject. The operational-level interviewees were in the majority since those workers were usually specialized in one or a few tasks along the whole process. Data were collected in respect of the different processes, in the same order as the different operations. Finally the aim was to check that all the specifications, standards and procedures were met, and to identify the different areas were possible improvements could be made.

FRAME OF REFERENCE

Value stream mapping

VSM is a visualization tool. It gives an overall picture of the production process, bringing together all kind of information as product flow, information flow, production time and inventory level (Bragila et al., 2006). The link between all these data is easily perceived, and facilitates the analysis of the system (Lasa et al., 2008). To complete the study, the tool can map, not only an internal productive process, but also an entire supply chain. Based on this map, companies have an overview of the current process and can redesign it to face the competitiveness of the market (ibid.). Mapping each product family flow facilitates identification of wastes in the system. The main objective is to focus on customers' demand and eliminate unnecessary non-value added activities, in order to reduce the product lead time by creating a pull system (Liker, 2004; Braglia et al., 2006). However, the VSM tool considers only technical issues; while companies also have to face social issues which can have significant effect on production processes. The VSM method is mainly concerned about the process part since its aim is to eliminate waste and to standardize and stabilize the process before moving to the next stage which takes care of people and partners (Liker, 2004). When dealing with a complex process proposing highly customized product to the market, the VSM has to be replace by other tools (Braglia *et al.*, 2006).

Closed loop supply chain

The concept of closed-loop supply chain appears mostly within reverse logistics and recycling. It differs from the usual forward supply chains since it includes a return process that can't be found in forward supply chains, where the end customer equals to the end of the process. A closed-loop supply chain includes a forward supply chain plus other activities such as reverse logistics operations to bring the product back from points of use to points of dispositions (GUIDE *et al.*, 2003a). With return policies, shortened life cycles and environmental legislation, the reverse part of the closed-loop supply chain is of growing interest, and improving the handling of returns is the new challenge companies have to face to remain competitive. According to GUIDE *et al.* (2003b), one of the most important challenges is planning, since the return flow is not accurately predictable. The planning challenges are the uncertain timing and quantity of returns, the need to balance the returns and the demand, as well as the uncertainty in materials recovered from the returned items. Closed-loop supply chains generate technical challenges, as highlighted by FLAPPER *et al.* (2005). Some closed-loop supply chains require a product redesign, or a distribution process redesign. In most supply chains the response time in the forward part of the supply chain (from the raw materials supplier to the end customer) is seen as essential to remain competitive and get the customers' preference. However it is often neglected in the reverse chain what may result in a value loss: most of the value in the remanufactured products is lost when they hit the market again. This is especially true in the clockspeed industry where products' value decreases rapidly. It is also applicable on the linen airport industry since linen going back to the laundry once used may not be reusable due to rucks, permanent stains, etc.

Airport logistics

According to Norin (2008) and Lindh et al. (2007), airport logistics are defined as the planning and control of all resources and information that create a value for the customer utilizing the airport. The most complex process that occurs at an airport, which is the one of interest here, is the turnaround process, when an aircraft is on the ground between its arrival and its departure. This process involves almost all actors operating on the airport, and is connected to other activities, on the airport's airside, the terminals, and on the airport's landside. Wu and Caves (2002) describe the operation of aircraft turnaround activities at an airport and conclude that the punctuality of aircraft rotation relies on both the design of aircraft rotation schedules and the operational efficiency of aircraft turnarounds. The length of the cleaning and catering parts of this turnaround process depends on the aircraft's size, on the flight characteristics (short-, medium-, long haul and destination), and on the arrival and departure times for the considered aircraft.

THE CASE

The actors in the case

Air France

Air France was founded in 1933 by merging four major French air transport companies. In year 2000, the SkyTeam alliance is created, regrouping Air France, Delta Airlines, Korean Air and Aero Mexico. This alliance allows its members to increase the number of possible destinations, with code sharing and a better transfer service for passengers between flight from alliance members. It represents today 16,787 daily flights, over 905 destinations in 169 countries, serving 462 million passengers (AIR FRANCE, 2009). It currently regroups 14 companies, and is the second global air transport alliance regarding transported passengers/kilometre.

Servair and ACNA

Servair, with catering and cleaning as main services, was created by Air France in 1971 and started to operate in 1974. During the 1980s Servair expands and settles in the USA. In the early 1990s, the company starts to specialize its business and creates new subsidiaries such as ACNA for cleaning and fitting the aircrafts.

Laundries

Air France subcontracts its linen processing activities to several laundries; two industrial and four laundries adapted for employment of handicapped people. The two industrial laundries are namely *Magic Rambo* and *RLD/PLH*. The laundries adapted for employment of handicapped people are: *La Gabrielle*, *AIA*, *Les Amis de L'Atelier*, and *Alter Ego*. In this case the competition rules are different than regarding usual industries since those companies are helped by the government to remain cost effective and competitive regarding usual industries.

The description of the flow

The flow that has been studied is divided into several sub-flows that depend on the item reference considered. The flow looks like a loop, starting and ending at the aircraft, on the airport. When an aircraft arrives at one of the two Parisian airports, and once all the passengers have left it, it is unloaded and the linen is brought back to the catering centre that takes care of that plane. The catering centre differs depending on the geographical area from which the aircraft comes from. At the catering centre, a sorting operation takes place first, often only to separate linen from other reusable items and/or non-reusable items. The linen is then picked up by the haulier. This haulier is owned by the laundry in the case of industrial laundries. For laundries adapted for handicapped people employment, this transport operation is done by the industrial laundries. Since different articles require different processes, Air France has to deal with several laundries each specialized in certain article/process. The linen is processed at the laundries, where it is then re-packed and sent back to the catering centres by the same haulier. The catering centre then loads the aircrafts and here ends the loop. However, due to specificities in packaging and/or in rules and regulations, this simple loop can be very distorted regarding the considered items. The distortions are caused by the following necessary actions:

- checking the packed linen; the certified supplier has to make the safety controls on each element in the package and deliver a safety certificate.
- if the supplier of the package is not certified, every container has to be fully checked by a certified supplier.
- loading and unloading of an aircraft can be done by regulated suppliers only.

FINDINGS FROM THE STUDY

The Project Organisation.

It is recommended to start each VSM process by building a specific team (LIKER, 2004; LASA *et al.*, 2008; HINES *et al.,* 1999) and the same has been done in this study. Servair started the project on its internal processes with the major actor of the project being Servair Method / Research & Development Department (hereafter SMRDD); they included Air France, represented by Inflight Product Logistics Department (hereafter IPLD), in order to have a supply chain approach of the linen process. ACNA, who is in charge of the cabin and cleaning equipment, was also involved as they are responsible for loading the linen and other equipment on board, they had a good overview of the processes. Even if the literature encourages to include all the actors involved in the product process, industrial laundries and ADT were not included in the VSM team due to Air France and Servair internal policies. The next step in the process was to define each team members' role in the VSM study in accordance with LASA *et al.* (2008) recommendations. The SMRRD was the project manager and also had the coordinator's duties. They were responsible for designing the maps and for the communication inside the team. Air France and ACNA were included in the study for their process knowledge; their main role was to facilitate the map creation, providing all data needed by Servair. For instance, ACNA had all the information considering the process from the laundries delivery till the airplane loading. Air France was giving all the information that was necessary about the laundries internal process, the product specificity and the safety.

Even if Servair claimed to have all the lean knowledge needed to efficiently manage the process, they did not act as experts since the team was not trained to VSM method. The SMRDD was the only team member educated by a consulting company specialized in the lean implementation. According to the LIKER (2004) training is a critical point when it comes to the implementation of the VSM tools. It is necessary that the group has the same knowledge on the technique and on the symbols used. They have to be able to give a common definition that will be used all along the project and, by doing so, avoid misunderstanding and frustration. However, during the first presentation of the VSM project at Air France, the method was quickly explained by Servair as an efficient way to reduce costs in the whole supply chain. Examples have been given to illustrate this efficiency and the expected outcomes of a VSM project, applied on the linen process, were stated. For instance, the Toyota case and others manufacturing examples were given to illustrate the strength of the method. Nevertheless, no explanations were given about the way the method had to be applied or how does it work. The expected outcomes were forecasted based on the potential benefits that could be gained by shortening the chain. SMRDD suggested at the very begining that there were too many actors involved in the linen process, thus, eliminating some of them would be a quick way of making profits.

The VSM process begun with the aim to map and analyse the current linen process, find improvement opportunities and implemented the changes in six months. Weekly meetings were scheduled with all team members and a small group was formed to work on the subject on a daily basis. However, they were not working together on the same subject, each member working on its area of expertise. After each weekly meeting, goals were set for the working group, considering the study progress. They usually communicated through e-mail, phone calls and small reunions to settle differences. The main objective was to make the CSM as realistic as possible first, and then, to find an improvement responding to all the actors' constraints, mentioned during the main meeting, and that could be easily put in place. To sum up, the working group was supposed to share information and draw the maps, and the VSM team, composed with top managers, made all the discussion and all decisions.

The Value Stream Mapping Process the blanket Y

At the beginning of the project, Servair presented various state maps at Air France. Based on their knowledge and other experiences in VSM, they had done different studies on other products than linen and had concluded that this product family represented the highest cost to the company. In fact, compared to other processes, it had the longest lead time, the highest volume, the biggest inventory buffers and a lot of actors were involved. Thus, in order to reach easily their objective concerning costs reduction, the linen product family appeared to be the process with the best improvements opportunities and therefore most interesting for this VSM project. However, as the linen product family process was very complex with great variety of products, it was necessary to narrow the study to a specific product. Finally the blanket Y was chosen.

Creation of the Current State Map (CSM)

Servair has mapped the blankets Y process based on its preliminary study. The first CSM was presented to Air France and ACNA; missing pieces of information were listed, and each actor tried to identified them. In fact, due to the lack of resources and time, all those data were extracted from contracts, internal procedures and from the computerized management tool developed by Air France.

None of the actors was able to quantify the inventory level at any stage of the process. This data was first supposed to be extracted from Air France computerized management system but as this program was not fully completed and tested, the displayed information was not reliable. In the CSM the value-added and non value-added times were calculated based on the cycle time and the lead-time of each activity. The first question to be raised was about the large amount of non value-added activities in the process. They represented nearly 95% of the total cycle time of the blankets Y process. By analysing this figure, the team realized that there was a huge improvement opportunity leading to a significant cost reduction.

Creation of the Future State Map (FSM)

The takt time was calculated by Servair to give an idea of the production rate needed to reach the customers' requirements as suggested by LASA ET AL. (2008). The information, taken as a basis for its evaluation was the Air France Long Haul Flight program. According to the literature, the takt time has to be used in the CSM analysis as an effective tool for redesigning the work cells and stabilizing the production system. Although a lot of guidelines are available in the literature (LASA *et al.*, 2008) the team decided to find the possible improvements by searching for specific wastes such as inventory, unnecessary transport and complex processes. Their choice was driven by their will to reduce cost rapidly. They planned to cut the inventory, eliminating ACNA's subsidiary ADT. The process time was supposed to be significantly reduced, creating a smooth flow controlled by ACNA. As ADT was involved in nearly all the products processes, this change would interfere in their performance during the implementation time. Besides, this breach of contract could be a delicate issue for ACNA; not only they would have to end an on-going contract but they would have to take over all ADT activities. However, it was considered as a good solution both by Servair, ACNA and Air France.

Development of the Action Plan

To accomplish the stated changes, specific assignments had to be done by each team member to evaluate their feasibility and consequences on the whole linen process. First, ACNA had to find a way to end its contract with its subcontractor. Then, the company had to estimate its own capacity to respond to Air France requirements. The customer had clearly stated its willingness to keep the process efficiency in term of quality and safety.

Concerning Air France, possibilities for laundry process modification had to be discussed with the top management and the purchasing department. The consensus that had to be found was related to the daily delivery. Such changes had to be negotiated with the laundries managers in order to find a solution that will satisfy the final customer demand and the process constrains. It was decided that all the improvement suggestions had to be discussed thoroughly before the implementation. During the study unexpected events, explained below, had occurred shattering the whole VSM team work.

Air France Internal Changes

Air France was informed of a new product launching, managed by its New Product Development Department (NPDD). Such changes were linked to the lack of brand new Blankets Y in the current product range and a new fleet creation. The new blanket, named Y08, was supposed to gradually replace the older one. This launching strategy led to some coordination difficulties as both blankets were used at the same time. The differences between the two blankets were their physical aspect and their cleaning process. The blanket Y08 could be washed whereas the older one could not and needed a dry-cleaning process; therefore the product flow had to change as each laundry had its own cleaning process specialization. This change was part of the company's policy of working more with laundries adapted for handicapped people. The problem is that this laundry does not perform a dry-cleaning process and thus could not take the blanket Y market. As explained earlier, Air France wanted to extend its circle of partner working with handicapped people in order to obtain financial advantages from the French government. Thus, as their higher product volume concerning the linen was the blanket Y, the Air France NPDD decided to elaborate a new blanket design which would be cleaned by the laundries adapted for handicapped people employment.

Consequently the cleaning blanket process had to be divided:

- in short-term between two industrial laundries
- in long-term between these two industrial laundries and one adapted for handicapped people employment

The need to do it in two stages was linked to the volume of blanket Y that had to be delivered to ACNA every days. In order to avoid shortages leading to airplane delay, it had to be done by industrial laundries which had the resources and capacity needed to respond to the demand. Then it was supposed to gradually move to the adapted laundries. Thus due to these internal changes the CSM was no longer accurate.

At the same time, the specific software used to manage the ordering process, was modified and implemented in the system. Air France required every actor, dealing with linen, to use this program, as communication tool and for ordering product, confirming deliveries, stating inventory level. The objective was to have a real time overview of the inventory and stock levels in order to reduce them and identify problem areas. Although the blankets were supposed to be reusable the stock level showed the discrepancies that result in financial losses.

DISCUSSION

The Lack of Preparation

Availability of resources, team members' education and process instability were the critical factors that led to the failure of this study. Servair undertook too many VSM studies at the same time, and thus did not have enough time to educate all the actors involved in the program. This led to misunderstanding, frustration and unnecessary conflicts during the process. The lean principles were not respected, and this could also explain some mistakes made during the project. The fact that the motivation behind the study was to make huge profits on a short-term period led to numerous mistakes. Furthermore, the on-going changes all over the organisation had disturbed the VSM project. The linen process was not stable, and thus, the state map was not accurate for longer than two or three days. The process had to be reiterated all over again, frustrating the team members and creating a conflicted work environment. People did not worked together to find the best solution; instead they only criticized each other. The focus should be on the VSM process and how to conduct it properly and not to run to the conclusions for improvements. All of the frustration could have been avoided by clear communication between the members.

The Complex Environment

The passenger transport industry is subjected to a lot of constrains; the main one is the safety issue. The regulation in this area is very strict and therefore limits the application of possible solutions. For instance, laundries taking care of the double-carrying blankets bags had to have a specific licence to work on this process. The working area has to be closed, and only authorized employee can enter this production zone. All the training and certification could take a while and had to be financed. Furthermore, Air France internal policy had also been a major constrain in developing a good VSM process. The policy has as an objective to work with companies adapted for handicapped people employment. This policy is motivated by the fact that the government subsidizes companies employing handicapped people; the subsidy is proportional to the number of handicapped employees working in the organisation. This is why Air France did not want to change nor end its relationship with the laundries adapted for handicapped people. All this complexity cannot be analysed in the traditional VSM process. As the literature suggests this method is mainly effective on technical aspects; on social and political issues the method is not efficient even if they have an important impact on the production process.

CONCLUSION

The Value Stream Mapping technique is, foremost, a visualizing tool, used to redesign a company's production process, considering the Lean Production principles. In order to be effective, this method needs a well trained, cross-functional team, working together on a stable and standardized process, with the intention of eliminating all kind of wastes from it. This study shows the key factors and the limits of the Value Stream Mapping process. VSM process should start with thorough explanation of the method; the lean philosophy has to be understood by the members involved in the project. A preparation phase has to make sure that the VSM tool is adapted to current situation. In this preparation phase the scope of the project has to be clearly defined and based on accurate figures. Unrealistic expectation leads to frustration and waste of time and resources. Furthermore, all needed resources have to be identified and trained to the method. They all have to "speak and understand" the same language. The communication between the members of the team is of a crucial importance. Finally, operational level employees should be involved in the VSM team so that the improvements suggested during the study are realistic and achievable. Last but not least risk analysis of each improvement measure should be done in order to avoid the situation with short-term benefits that might lead to long-term losses.

REFERENCES

Air France (2009) Corporate Social Responsibility Report 2008-09.

Braglia M., Carmignani G. and Zammori F. (2006): A New Value Stream Mapping Approach for Complex Production Systems, International Journal of Production Research, Volume 44, Issue 18, Pages 3929-3952.

Flapper S.D.P., Van Nunen J.A.E.E. and Van Wassenhove L.N. (2005) Managing Closed-Loop Supply Chains, Ed. Springer, ISBN 3540406980.

Guide V.D.R., Harrisson T.P. And Van Wassenhove L.N. (2003a): The Challenge of Closed-Loop Supply Chains, Interfaces, Volume 33, Issue 6, Pages 3-6.

Guide V.D.R., Jayaraman V. and Linton J.D. (2003b): Building Contingency Planning for Closed-Loop Supply Chains with Product Recovery, Journal of Operations Management, Volume 21, Issue 3, Pages 259-279.

Hanlon J.P. (1999): Global Airlines – Competition in a Transnational Industry, Ed. Butterworth-Heinemann, ISBN 0750643501.

Hines P., Rich N. and Esain A. (1999) Value Stream Mapping : A Distribution Industry Application, Benchmarking: An International Journal, Volume 6, Issue 1, Pages 60-77.

Lasa I.S., Laburu C.O. and Castro Vila R. (2008) An Evaluation Of The Value Stream Mapping Tool, Business Process Management Journal , Volume 14, Issue 1, Pages 39-52.

Liker J.K. (2004): The Toyota Way, Ed. McGraw-Hill, ISBN 9780071392310.

Lindh A., Andersson T., Värbrand P. and Yuan D. (2007): Airport Logistics – Integration of ATM and Ground Processes, Linköping University, [online] available from <http://webstaff.itn.liu.se/~toban/atm2007-airportlogistics.pdf>, consulted on 20091015.

Norin A. (2008): Airport Logistics – Modelling and Optimizing the Turn-Around Process, Linköping University, ISBN 9789173937443.

Power M. (1994) The Audit Explosion, Ed. Demos, ISBN 9781898309307.

Von Roessing R. (2002): Auditing Business Continuity: Global Best Practices, Ed. Rothstein Associates, ISBN 9781931332156.

Wu, C.-L. and R.E. Caves (2002) Modelling of aircraft rotation in a multiple airport environment, Transportation Research Part E 38 (2002) 265–277

CARGO FLOW DEMAND ANALYSIS FOR MAJOR ROADS IN MALAYSIA

I R Endut[1,2], H S Jaafar[1,3], S Mohamad[1,3] M S Mat-Daud[1]
[1]Malaysian Institute of Transport (MITRANS), Universiti Teknologi MARA, 40450 Shah ALam, Selangor, Malaysia
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah ALam, Selangor, Malaysia
[3]Faculty of Business, Universiti Teknologi MARA, 40450 Shah ALam, Selangor, Malaysia

INTRODUCTION

The volume of traffic in the past several years has rapidly increased the capacities of the roads and highways in Malaysia. It is important to understand the dynamics of traffic flow and obtain a forecasting model to estimate the growth. Logistic industry serves as an important link in the initiative to enhance Malaysian performance in industrialization and international trade (MITI, 2003). The progress of the industry has an impact on the pace of nation's industrialization and its competitiveness in international trade. The logistic industry comprises transport as it core element and complemented by various related services, such as warehousing, forwarding, and other value-added services (MITI, 2003). The transport sub-sector meanwhile covers port, airports, road, railway and inland haulage services.

Cargo transport is one of backbones in any industrial system (Willis, 2010; Sgouridis, 2003). Despite it supporting the transportation of commodities and processed raw materials, cargo transport is also important to transport end products to the local and international markets (FHWA, 2010). The Malaysian economy also depends on cargo transport. Between the years of 2007 and 2011, the transport and communications sectors are expected to achieve an average annual growth of 5.5%, for the overall Gross Domestic Product (GDP) while the total value of the transport and communications GDP is expected to rise to US$17.7bn by 2011, representing 7.4% of Malaysia's GDP (Statistics department, 2010).

The importance of the cargo transport can be seen very clearly; domestic manufacturers rely on cargo transport for the source of raw materials to produce goods; wholesalers and retailers depend on cargo transport to obtain specialised goods; and households and small businesses depend on cargo transport to deliver purchases directly to them. With the burst of the 'dotcom bubble' in the 21st century, cargo transport is expected to cover a larger geographic area and be more responsive to user needs (Hu, 2001; Holguin-Veras and Thorson, 2003). This has been agreed by leading shipping companies during the World Express and Mail Conference 1996 in Brussels, where out of the 50 shipping participants, more than half cited 'dotcom bubble' or e-commerce as the most important factor that drove their growth in business (Holguin-Veras and Thorson, 2003).

In addition to the economy growth over the next several decades, the demand for goods will only increase (Holguin-Veras and Thorson, 2003; Sgouridis, 2003). As trucks are dominant in cargo transport, the capability of roads and highways to cater the volume is a wonder. Based on the estimated container throughput and average daily truck trip as shown in Table 1, the transportation system in Malaysia has moved an average of 10013 TEUs of cargo per day from Port Klang and 8241 TEUs per day from Port Tanjung Pelepas in 2009. More than half of the TEUs moved were either as an import from or export to another country and less than 25 percent were moved within the local areas as shown in Table 2.

Table 1: Containerised Throughput and Estimated Average Daily Truck Trips from 2 Top Seaports, 2009 (Port, 2010)

Port	*Annual TEU*	*Annual one way trips (assuming 2 TEU per truck)*	*Average daily one way truck trip*
Port Klang	*7,309,779*	*3,654,890*	*10013*
Tangjung Pelepas Port	*6,016,451*	*3,008,226*	*8241*

Table 2: Statistical Data about Transportation of Cargoes in Malaysia from 2005 to 2009 (Source: Road Transport Department, 2010)

Year	**Types of Traffic**			**Total Traffic**
	National traffic	**Import**	**Export**	
2005	805,157	1,342,901	1,276,661	3,424,719
2006	836,579	1,403,946	1,367,625	3,608,150
2007	871,234	1,527,893	1,474,193	3,873,320
2008	909,243	1,629,977	1,598,544	4,137,764
2009	936,222	1,515,743	1,478,354	3,930,319

It is noted that the role of cargo transport as the conveyor of goods is increasing. Though there is a pressure from the community and environmental group regarding the negative impact in the cargo's activities (air quality problem, noise pollution, pavement damages, accident problem and etc.), there is no doubt that cargo transportation has made a significant contribution to the vitality of the nation's economy (Jonnavithula, 2004).

As the objective of this study is to analyse cargo flow in Malaysia, it is essential to understand the flow that happens in Malaysia and thus its relationship with the years, time and district as these factors will be the important elements in identifying the areas that generate cargo demand.

METHODOLOGY

The aim of the study was to analyse the cargo flow in Malaysia from 2005 to 2009, the approach used was the general analysis of the cargo growth during 2005 to 2009, the correlation analysis was used to determine the strength between the factors of year, time and district in determining the area that generate and attract the cargo demand, and lastly the projection of future growth of the cargo based on the historical trend by using compound growth factor to determine the future cargo demand.

CARGO FLOW IN MALAYSIA

Cargo traffic flow can be represented in many different ways, depending on the mode, type of vehicle, and commodity (Hesse and Rodrigue, 2008). A common representation that is usually measured is in terms of the number of vehicles where one twenty-foot equivalent units (TEU) represent a standard of 20-foot container.

In general, there are four controlling factors that impact cargo demand (FHWA, 2010). These factors can be broadly grouped into the following categories which are economic structure, industry supply chains and logistics, cargo infrastructure/modes, and cargo traffic flows. Every factor has an impact on the cargo demand analysis, for example, cargo demand has a direct correlation with the type and amount of economic activity in a region and the types of modes that carry cargo provide different types of services.

From the analysis of cargo flow from 2005 to 2009, it can be seen that trucks registration (including van for commercial goods) on average has increased more than 17%. The annual growth is 3.55% to 5.02%. This situation is supporting the data publish by the Road Transport Department in Table 3. Majority of these movements contribute from the international trade activities (import and export).

Table 3 : Trucks Registration by Year (Source: Department of Transportation, December 2010)

Year	Trucks Numbers	Volume increase	% increase
2005	807,895		
2006	836,579	2868	3.55
2007	871,234	3466	4.14
2008	914,967	4373	5.02
2009	949,698	3473	3.80
2010			

Based on the product classification, the growth in export activities contributes largely from fixed vegetable oils and fats, crude, refined or fractionated and gas, and manufactured; while for the import activities, it is contributed largely by petroleum, petroleum products and related materials (Statistics Department, 2010).

Intermediate goods contribute about RM331.4 billion to the total imports, while capital goods contribute about RM69.1 billion. Consumption goods on the other hand contribute about RM31.3 billion (Statistics department, 2010). With the continuing of economy growth in 2011, cargos handling in ports are expected to achieve a 7 percent growth, in both the import and export activities, and thus make the transportation by truck become more important.

Malaysia’s growth in exports was contributed by the higher exports to the People’s Republic of China (RM894.6 million), Japan (RM853.9 million) and Taiwan (RM444.1 million) which amounted to RM2.2 billion (83.3%) of the total increase, year on year. As for the imports, the growth was attributed mainly to higher imports from the Republic of Singapore (RM656.9 million), Japan (RM611.1 million), the United States of America (RM448.3 million) and the Republic of Indonesia (RM424.0 million) which contributed 85.1% or RM2.1 billion of the total increase (Statistics Department, 2010).

CORRELATION ANALYSIS: VOLUME, DISTRICT, YEAR AND TIME.

This analysis is done to know the strength of the relationship for each preliminary element (volume, district, year and time) and this analysis takes the Selangor state as the example. Selangor is chosen because it is where Port Klang, the busiest port in Malaysia, is located. The analysis consists of the correlation between the volume versus time, volume versus years and volume versus district. This analysis is done in order to know the factors that influence the demand of the cargo truck at one area. The fist analysis is the correlation between the volume and time. This analysis is based on the data provided by the Public Work Department (PWD). This analysis is done to distinguish if the peak hour suggested in the report represents the real peak hour for truck traffic. From the results, R^2 for Pearson's correlation was 0. 286, which indicated that the peak hour time provided in the report did not represent the peak hour for truck traffic.

The second analysis is the correlation between year and volume. This analysis is done to know if the year (usually related to economic indicators) is related to the demand for truck cargo. From the results, the value of R^2 was 1.00, indicating that the year and the demand for truck cargo had a strong relationship. These results also proved that the economy was one of the factors affecting the cargo demand as more active the economy, more trucks were needed to transfer the goods.

The last correlation analysis is between the volume and the district. This analysis is done to find out if district plays an important role in generating the demand for truck cargo. The R^2 for this analysis was 0.521, and from the guideline provided by Cohen (1988), the results were considered as medium, which meant that some of the districts were responsible for generating truck cargo while some were not.

From the overall results provided by the correlation analysis, it could be understood that the year and district played an important role in generating and attracting the cargo demand.

PROJECTION OF CARGO TRANSPORTATION FOR 2020

Using the above secondary data, the projection for cargo truck in 2020 was conducted. In projecting the cargo truck growth, there were two methods that could be applied which were to apply the growth factor to the baseline cargo traffic data or apply the growth factor to the economic activity. The common method used to project future demand was based on the baseline cargo traffic data.

In this method, the growth factor was calculated based on the historical traffic information to the baseline traffic data. This technique is frequently used by the department of transportation and other planning agencies, to establish rough estimates of growth for a variety of demand and is certainly applicable in establishing the cargo traffic for the cargo component of a transportation plan, programme, or project design.

In forecast of truck cargo by trip, compound growth method has been done in this analysis (Federal Highway Adinistration, 2007). By assuming that cargo flow grows in a compound fashion, the annual growth factor will be the ratio of the flow in the second and first raise to a power which is the inverse of the number of years between the first and second observations. The formula of the growth factor is as follows:

$$AGF = (F_2/F_1)^{1/(Y2-Y1)}$$

Where F_1 is cargo flow in year Y_1 and F_2 is cargo demand in year Y_2. This can also be expressed as a compound annual growth rate by subtracting 100 percent from the AGF.

The compound growth factor can then be applied to predict future demand (F_3) for some future year (Y_3) as follows:

$$F_3 = F_2{*}AGF^{(Y3-Y2)}$$

If more than two years of historical data are available for the variable to be forecast, this data can be used to solve a power regression according to the formula:

$$F(n) = Constant{*}AGF^{(n)}$$

Where n is the number of years from the first observation and Constant and AGF are found from the linear regression. In this case, with an R-square of 0.7972 (Figure 2) the coefficients therefore are:

$$F(Y) = 3{,}424{,}726{*}(1.035)^{(n)}$$

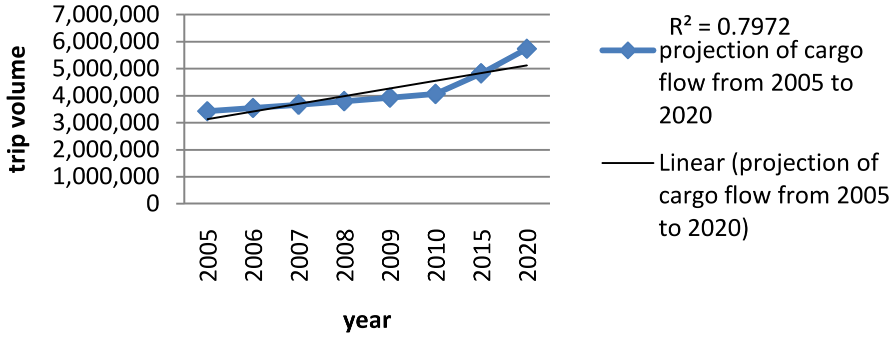


Figure 2: Projection of Cargo Flow from 2005 to 2020

Table 4: Projection of Cargo flow in Malaysia from 2005 to 2020 (Source : Road Transport Department, 2010)

Year	Traffic	Ln (Traffic)	Years from 2005	Compound Regression
2005	3,424,719	15.04653	0	3,424,726
2006	3,608,150	15.09871	1	3,544,591
2007	3,873,320	15.16962	2	3,668,652
2008	4,137,764	15.23567	3	3,797,054
2009	3,930,319	15.18423	4	3,929,951
2010	-	-	5	4,067,500
2015	-	-	10	4,830,914
2020	-	-	15	5,737,610

From Figure 2 and Table 4, it can be concluded that the cargo truck growth projected will increase to more than 5 million in 2020 and since the value of R^2 is 0.7972 (near to 1.0), then the results are considered acceptable.

CONCLUSION

Currently, the development of cargo planning model in Malaysia has a limitation in practical and reliable tools. One of the limitations is due to the complexity in cargo data collection. Because of the lack in data collection, the following problems are observed: loss of the cargo flow volume, increase of delivery costs, lack of coordination in usage of modes of transport, and etc.

In conclusion, from the analysis of the current status of cargo truck (based on the secondary data), the following results are observed:

- Import/export activities contributed a major portion to the volume of cargo truck on the road and with the economy growth in 2011, the numbers would keep increasing.
- Majority of the import activities on the roadways were from the intermediate goods; while for export activities, they were from the electric and electronic products.
- The Malaysian top ten export destinations were the Republic of Singapore, the People’s Republic of China, the European Union (EU), Japan, the United States of America, Thailand, Hong Kong, Australia, the Republic of Korea and India; meanwhile, the top ten destinations for import activities were the People’s Republic of China, Japan, the Republic of Singapore, the United States of America, the EU, Thailand, the Republic of Indonesia, the Republic of Korea, Taiwan and Hong Kong.

- District and year played an important role in generating cargo truck demand. The year was related to the economy growth while the district was related to the location of the demand either for the origin or destination.
- Based on the results of the projected cargo truck demand, the number of trucks that will use the highway and route ways will be increased to more than 5 million in 2020, which will contribute to the traffic problem and other problems as well as not handled carefully.

ACKNOWLEDGEMENTS

The authors acknowledge the Malaysian Institute of Transport (MITRANS), Universiti Technologi MARA (UiTM), and Malaysian Logistic Council (MLC) for providing financial support for this research. Thanks are extended to Department of Statistics for providing information on the cargo flow volume.

REFERENCES

Cohen, J (1988) Statistical Power Analysis for the behavioural Sciences. 2nd Edition, Lawrence Erlbaum Associates Inc,.

Federal Highway Administration (2007) Quick Response Freight Manual II, http://ops.fhwa.dot.gov/freight/publications/qrfm2/qrfm.pdf. Assessed on 15 January 2011.

FHWA (2010) Freight Management Operations http://ops.fhwa.dot.gov/freight/freight_analysis/improve_econ/ Assessed on 20 January 2011

Holguin-Veras, J., and Thorson, E.,(2002), *Trip Length Distribution in commodity Based and Trip-based Cargo Demand Modelling: Investigation of Relationships*, Transportation Research Record 1707, TRB, National Research Council, Washington, D.C., pp. 37-48.

Hu, P. (2001). Developing an E-sensible transportation system: what are the research and data needs? Transportation Research News 216: 4–8, September–October 2001, Transportation Research board, Washington DC.

MITI (2003) Industry, investment, trade and productivity performance. Fourth Quarter report. :http://www.miti.gov.my/cms/content. Accessed on date: 20 November 2010 Road Transport Department, 2010. Website: http://portal.jpj.gov.my/ Accessed on 19 January 2011

Sgouridis P.S., (2003), *Freight Transportation in Malaysia: Technological and Organizational Issues from an ITS Perspective,* Massachusetts Institute of Technology

Statistics Department, (2010). Website: www.statistics.gov.my Accessed on 2 January 2011.

United States Department Transportation-Federal Highway Administration (FHWA), (2010), *Quick Response Freight Manual II*. Website: http://www.fhwa.dot.gov/

Willis, S., (2010), *the Infrastructure for Freight Transport in Vietnam*. Website: http://ezinemark.com/

BARRIERS TO SUPPLY CHAIN INTEGRATION
A COMBINED VIEW OF DIFFERENT PARTNERS IN PORT INDUSTRY

Badi Almotairi
Division of Logistics and Transport, Chalmers University of Technology, 41296 Gothenburg, Sweden.
E-mail: badi@chalmers.se, Tel: +46317725165; Fax: +46317723485

ABSTRACT
Purpose of this paper
The purpose of this paper is to determine barriers to supply chain integration in port industry and to develop a combined view of different partners in port industry concerning viable impediments to an integrated logistics platform.

The purpose of this paper is to determine barriers to supply chain integration in port industry and to develop a combined view of different partners in port industry concerning viable impediments to an integrated logistics platform.

Design/methodology/approach
To prepare this paper, a triangulation method consisting of a literature review, a cross-functional survey, and in-depth case studies have been carried out to accomplish the purpose. To analyze the data, a barrier's framework was developed using a well-known supply chain management (SCM) framework components'.

Findings
The research shows that the most common barriers fall within the proposed barrier's framework construct: network barriers, process barriers, and management barriers. Under these construct, deficiency in information system (IS) and information technology (IT), inconsistent operating goals, and supply chain power inequalities are major barriers to supply chain integration.

Practical implications (if applicable)
The paper provides new insight into understanding the barriers to supply chain integration in port industry. The literature review and case studies analysis provide academics and practitioners with a combined view to enhance supply chain integration.

What is original/value of paper
The idea behind the study is to contribute to a better understanding of the barriers within the maritime supply chain. The paper uses triangulation methodology for examining barriers to supply chain integration in port industry at multiple levels.

Keywords:
Barriers; Integrated logistics platform; Port industry; Supply chain management; Transportation.

1. INTRODUCTION
The development of global supply chains has increased the pressure on maritime hauling, seaport operations and inland freight distribution (Notteboom and Rodrigue, 2005; Almotairi, 2010). This fact has stimulated port organization to search for ways of managing the business and their relationships with other supply chain members (Panayides, 2006). Hence, different strategies have been deployed to leverage the synergy effect, and more importantly is to create corporate customer value. One of these strategies aiming at integrating the sea/land interface with landside logistics is based on the concept of logistics platform (Almotairi and Stefansson, 2010).
Nevertheless, sustainable development of an integrated supply chain requires efficient and effective management of relational exchanges among enterprises with the ultimate

aim to create value to the end customers (Stevens, 1989; Lambert and Cooper, 2000; Skjoett-Larsen, 2000). Efforts to align objectives and to integrate activities across-company boundaries are known as supply chain management (SCM) initiatives (Lambert et al., 1998; Ballou, 1999; Poirier, 1999). As SCM is a boundary-spanning activity (Bowersox et al., 1999), determining and understanding barriers to supply chain integration can be an effective tool and further a mechanism that facilitates the synergy of business processes across supply chain (Fawcett et al., 2008; Richey et al., 2009).

While most of the studies devoted towards the positive outcomes of the supply chain integration, little efforts have been paid to determine enablers and barriers to supply chain integration. This fact highlighted by Pagell (2004), who is called for more research on the factors that enable and inhibit supply chain integration. More recently, Richey et al. (2009) admitted that research on the effects of the barriers to supply chain integration is still lacking. Thus, the current study follows the same trend in determining barriers to supply chain integration, but with focus in port industry context.

The purpose of this paper is to determine barriers to supply chain integration in port industry. To do so, a triangulation method consisting of a literature review, across functional survey, and face to face case studies have been carried out to accomplish the purpose. This is to ensure that the study captures the most important principle barriers within port industry. Moreover, a combined view of different partners in port industry contributed to a better understanding of the barriers exists within the maritime supply chain.

The paper structured as follows: next section provides the conceptual setting for the study, whereas the framework outlining barrier's construct that need to be examined across channel functions is complemented. The third section of the paper is devoted to the methodological approach and how the research process is accomplished. Finally, the research result and discussion part are followed by conclusion with short descriptions of the barrier's framework implications and its potential values.

2. A FRAMEWORK FOR BARRIERS TO SUPPLY CHAIN INTEGRATION

To better understand important barriers that exist within a specific supply chain setting; first we shed light on the term "barrier's" to supply chain within the logistics management context. Second is to identify and classify barriers that extracted from literature in accordance with the interrelated nature of SCM components. Today's business environment, in spite of tools and methods that contributed to an increasing level of integration, continues to be confronted by a wide-range of barriers. In order to achieve efficient and effective integrated logistics platform (ILP), these barriers need to be understood.

2.1 Defining the term barriers to supply chain

The term barriers to effective SCM have been defined by Fawcett et al. (2008) as follows:

"The resisting forces to strategic supply chain management, which come both from the nature of the organization itself and the people that compose the organization"

Moreover, the term barriers to supply chain can be expressed as a serious impediment to designing and implementing an effective process integration that hinder firms to identify and understand customer needs and wants (Fawcett and Magnan, 2001). Hence, the magnitude of the term barriers to supply chain goes beyond the firm boundaries to resemble almost upon each component of the SCM. Fawcett and Magnan (2002) argued that managers and scholars must not focus on one particular inhibitor or facilitator, but rather a holistic approach is the key to efficient supply chain integration.

2.2 Barriers to supply chain integration

Many firms are striving for higher competitive-edge through lean, efficient, and responsive supply chains—which can be achieved by overcoming the barriers that impede enhanced cooperation and more integrated decision making (Fawcett and Magnan, 2001; Fawcett and Magnan, 2002; Hofer and Knemeyer, 2009; Richey et al., 2009). To facilitate effective supply chain integration, scholars have taken different approaches for identifying and classifying barriers to supply chain integration. While some researchers delimit their research-work to identify barriers set within process integration/internal mechanisms (Richey et al., 2009), barriers under one of two headings: "inter-firm rivalry" and "managerial complexity" (Park and Ungson, 2001), other scholars have taken a wider-approach to address barriers to SCM fallen under misalignments in allying firm's process, structures, and culture (Fawcett and Magnan, 2001; Fawcett et al., 2008).

This study follows the later trend, which allowing a holistic approach for determining barriers to supply chain as suggested by (Fawcett and Magnan, 2001; Fawcett and Magnan, 2002; Fawcett et al., 2008). By building on Fawcett et al. (2008) research-work in identifying barriers and adapting to Lambert and Cooper (2000) SCM's framework, this research relates the identified barriers to SCM components. Figure 1 suggests that barriers to SCM components' include: network barriers, process barriers and management barriers. It is these findings that serve as the basis of our framework construct generation in the current study.

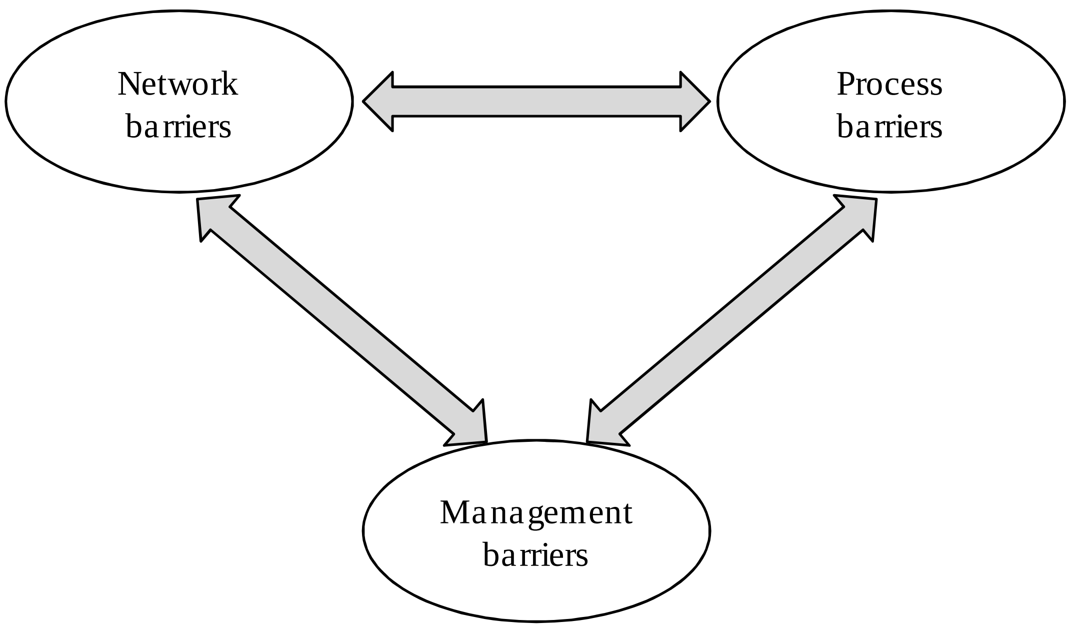


Figure 1. Framework for supply chain barriers

Table 1. Literature review—barriers to effective supply chain management adapted from Fawcett *et al.* (2008)

Barriers index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total
Network barriers																												
Lack of channel trust			X							X			X		X				X			X	X		X			8
SC power inequalities					X																						X	2
Resource constraints				X						X																		2
Complex SC networks						X																						1
Process barriers																												
Cross-functional conflict/turf protection	X	X	X				X	X	X		X	X	X		X	X	X				X	X		X	X			16
Inconsistence operating goals						X																						1
Management barriers																												
IS/IT deficiencies			X	X				X		X	X		X		X	X		X		X								10
Organizational structure	X										X			X				X		X	X			X	X	X		9
Lack of willingness to share information.						X																						1
Lack of willingness to shared risks and rewards						X																						1

Sources: 1 – Akkermans *et al.* (2004); 2 – Andraski (1998); 3 – Barratt (2004a); 4 – Bender (2000); 5 – Cox (1999); 6 – Fawcett *et al.* (2008); 7 – Frohlich (2002); 8 – Inger *et al.*(1995); 9 – Johnson *et al.* (2001); 10 – Kilpatrick and Factor (2000); 11 – La Londe (2003); 12 – La Londe and Masters (1994); 13 – Mentzer *et al.* (2000); 14 – Milligan (1999); 15 – Moberg *et al.* (2003); 16 – Monczka and Morgan (1997); 17 - Monczka and Morgan (1998b); 18 – Morgan (1997); 19 – Neuman and Samuels (1996); 20 – Pitera (2000); 21 – Quinn (1997a); 22 – Quinn (1999); 23 – Sheridan (1999); 24 – Smagalla (2004); 25 – Tyndall *et al.* (1998); 26 – van Hoekm *et al.* (1998); 27 - Zaheer *et al.* (1998)

2.3 Construct items generation

Cooper et al. (1997) and Lambert and Cooper (2000) developed a framework for SCM that constitute a closely interrelated nature of SCM's components. To support the paper objective, a new construct of barriers that aligns with Lambert and Cooper (2000) SCM framework was developed (see Figure 1). These construct of barriers include:

Network barriers concern obstacles that impede the structural relationships. It is the hindrance to the arrangement of the members of the supply chain and their relations. According to Lambert and Cooper (2000) network structure includes: the members of the supply chain, the structural dimensions of the network and the different types of process links across the supply chain;

Process barriers refer to impediments to activities and flows in the supply chains. Lambert and Cooper (2000) define process as a structure of activities designed for action with a focus on end customers and on the dynamic management of flows involving products, information, cash, knowledge, and/or ideas. Thus, any hindrance to these functional, and/or cross-functional activities can be classified within process barriers; and

Management barriers concern obstacles that impede fundamental management components. Lambert and Cooper (2000) divided fundamental management components into two separate groups: the physical and technical group, which include the most visible, tangible, measurable, and easy-to-change elements. The second is the managerial and behavioural group, which is less tangible and visible and is often difficult to assess and alter.

Based on the above barrier's framework construct, a pool of potential barriers index was adapted from Fawcett et al. (2008) research-work with the aid of researcher's expert in logistics management. The item generation purpose is to ensure that important barriers were included and that they were consistent with the proposed framework. The items were redefined with the aid of feedback provided by logistics experts (professors with knowledge of maritime logistics research and doctoral students' expert in the same field) in order to finalize substantive content and avoid duplication. More specifically, items that were of nature specific to manufacturing industries were eliminated and the final set of items was achieved as shown in Table 1. Notably, the goal was to keep barriers index that could be applicable for firms in a sample with completely diverse lines of business and logistics requirements.

In effect, the grouped barriers index (see Table 1) can be adequately incorporated in survey or case study and focus our efforts on these three constructs (network barriers, process barriers and management barriers). As SCM is a boundary-spanning activity (Bowersox, 1999), It is important to reiterate our desire to develop exhaustive wide-scale of barriers that cover different SCM components intended to be used as reference variables. However, while additional items for each dimension could have been added, their addition would have been contrary to the goals of this study and will divert our focus outside the circle of the maritime supply chain setting. The next section illustrates the methodological approach associated with the paper main goal.

3. METHODOLOGICAL APPROACH

Research methods ought to be selected based on the purpose and nature of the research undertaken (Yin, 2003). The research purpose is to determine barriers to supply chain integrations in port industry. To support the paper main objective and to strengthen our methodological rigorous, a triangulation method approach was used (Lewis, 1998; Scandura and Williams, 2000). This method includes a literature review as shown in Table 1, and a multi-method empirical approach in the form of cross-functional surveys and in-depth case studies as well.

Cross functional survey was deployed to capture how functional managers view barriers in their supply chain setting. As thus, a one-page barriers index was developed, and the preliminary survey was reviewed by several academics that familiar with the subject matter. Their feedback was used to modify the survey instrument. The final set of barriers index was exposed to four different groups of managers within the port industry: shipping line managers, terminal managers, port authority managers, and trucking company managers. The survey was conducted face-to-face with the previous stated managers in order to explain the presumed methodology and to eliminate potential bias. The final set of barriers index measured by a five-point Likert scale anchored by strongly disagree (1) and strongly agree (5). This is to indicate the degree of deficiency that each variable would cause to the port supply chain integration.

In-depth case studies were conducted in order to explore the "why" behind our survey findings (Yin, 2003). It was determined that interviews ought to be conducted with the same respondents in the early surveys. While the allocated respondents are managers in leading organizations in the port industry, their channel positions as key members in different stages of the supply chain allowed the cross-case analysis as suggested by (Eisenhardt, 1989). The insight gained by combining the surveys with the interviews yielded a rich and robust view of main barriers to modern port's supply chain integration practice.

4. RESULT AND DISCUSSION

The mean and standard deviation (SD) scores for the combined channels surveys were compiled and ranked. The ranks were then ordered according to the importance of each barrier to supply chain integration, and not by each proposed construct. Table 2 summaries the barriers evaluations synthesised from the cross-functional surveys. Furthermore, the data gathered from the interviews yielded more understanding and details about the ranked items from the surveys.

Table 2. Combined channels rankings of barriers

		Combined channel		
		Mean	SD	Rank
Barriers index				
Network barriers	Lack of channel trust	2,27	1,68	10
	SC power inequalities	3,27	1,74	3
	Resource constraints	2,45	1,51	9
	Complex SC networks	3,09	1,81	4
Process barriers	Cross-functional conflict /turf protection	2,73	1,74	7
	Inconsistence operating goals	3,36	1,69	2
Mgmt. Barriers	IS/IT deficiencies	3,73	1,79	1
	Organizational structure	3	1,84	5
	Lack of willingness to share information	2,64	1,69	8
	Lack of willingness to shared risks and rewards	2,91	0,94	6

The main causes for supply chains being unable to share and utilize resources are proposed to be congruent with the barrier's framework that discussed earlier: network barriers, process barriers, and management barriers.

The single greatest barrier revealed by the study is IS/IT deficiencies—receiving an average score of (mean = 3,73) among other barriers index. While this barrier belongs to the management construct, key managers emphasise that collaboration is information driven, and inadequate or incompatible information systems is a crucial barrier to collaboration. Interestingly, many of the visited ports were found to be under transition for acquiring flexible and easy to connect information systems.

The second important barrier is inconsistence operating goals with an average score (mean = 3,36) in total. This barrier attributed to the process barrier's construct, and senior managers indicated that the clear operating goals along the supply chain would definitely enhance the flow consistency; especially whereas the port industry contains a very complex networks interacting at different levels.

The third most important barrier is supply chain power inequalities—receiving an average score of (mean = 3,27) among other barriers. This barrier belongs to the network construct. The importance of this barrier comes from the fact that dominant firm in the supply chain (e.g. large shipping line, terminal operators, Etc) exercise their relational power to attain certain resources which not available for the other member-firms.

It is worthwhile to mention that these types of important barriers distributed along the proposed barrier's construct, but it seems to be that management barriers deserve more attention than other barriers in the proposed framework. This was evident since many of the interviewed mangers stress that fundamental management attributes (physical and technical as well as managerial and behavioural) is the key determinant to successful supply chain integration.

5. CONCLUSION AND IMPLICATIONS

Determining serious impediment to designing and implementing an effective supply chain in port industry is the main objective of this research. To the aim of this paper, barriers index adapted from Fawcett et al. (2008) grouped within a well-known SCM's framework (Lambert and Cooper, 2000). Based on that, the study proposed a tentative barrier's framework made of three main construct namely: network barriers, process barriers, and management barriers. The study reveals that:

- IS/IT deficiencies is the single greatest barrier to supply chain integration in the port arena as recognized by managers through the combined channel rankings and interviews;
- Second important barrier is inconsistent operating goals where supply chain processes have to be align along the supply chain; and
- Finally, supply chain power inequalities ranked as the third important barrier to supply chain integration while power converted to competitive advantage and sort of value chain mechanisms.

Managers believe that understanding the management barriers is the key determinant for successful supply chain integration. However, running parallel to optimize the effect of other barrier's construct will be the realistic view depending on the overall supply chain structure and design. Only then can proper understanding of the actual barriers to supply chain integration will leads to leverage integrated logistics platform and attain supply chain success.

REFERENCES:

Akkermans, H., Bogerd, P. and van Doremalen, J. (2004), "Travail, transparency and trust: A case study of computer-supported collaborative supply chain planning in high-tech electronics", European Journal of Operational Research, Vol. 153 No. 2, pp. 445-456.

Almotairi, B. (2010). The Port Logistics Platform. School of Technology Management and Economics. Gothenburg, Chalmers University of Technology. Licentiate.

Almotairi, B. and Stefansson, G. (2010), "Integrated Logistics Platform - An empirical analysis from the port industry", in The 22nd NOFOMA Conference Proceedings, Kolding, Denmark, pp. 565-580.

Andraski, J. C. (1998), "Leadership and the realization of supply chain collaboration", Journal of Business Logistics, Vol. 19 No. 2, pp. 9-11.

Ballou, R. H. (1999), Business Logistics Management: Planning, Organizing, and Controlling the Supply Chain, 4th ed, Prentice-Hall International, London.

Barratt, M. (2004), "Understanding the meaning of collaboration in the supply chain", Supply Chain Management: An International Journal, Vol. 9 No. 1, pp. 30-43.

Benders, P. S. (2000), "Debunking five supply chain Myths", Supply Chain Management Review, Vol. 4 No. 1, pp. 52-58.

Bowersox, D., Closs, D. J. and Stank, T. P. (1999), 21st Century Logistics: Making Supply Chain Integration a Reality, Council of Logistics Management, Oak Brook, IL.
Cooper, M. C., Lambert, D. M. and Pagh, J. D. (1997), "Supply Chain Management: More Than a New Name for Logistics", The International Journal of Logistics Management, Vol. 8 No. 1, pp. 1-14.
Cox, A. (1999), "Power, value and supply chain management", Supply Chain Management: An International Journal, Vol. 4 No. 4, pp. 167-175.
Eisenhardt, K. M. (1989), "Building Theories from Case Study Research", The Academy of Management Review, Vol. 14 No. 4, pp. 532-550.
Fawcett, S. E. and Magnan, G. M. (2001), Achieving World-Class Supply Chain Alignment: Benefits, Barriers, and Bridges, CAPS Research/Institute for Supply Management, Tempe, AZ.
Fawcett, S. E. and Magnan, G. M. (2002), "The rhetoric and reality of supply chain integration", International Journal of Physical Distribution & Logistics Management, Vol. 32 No. 5, pp. 339-361.
Fawcett, S. E., Magnan, G. M. and McCarter, M. W. (2008), "Benefits, barriers, and bridges to effective supply chain management", Supply Chain Management: An International Journal, Vol. 13 No. 1, pp. 35-48.
Frohlich, M. T. (2002), "e-integration in the supply chain: Barriers and performance", Decision Sciences, Vol. 33 No. 4, pp. 537-557.
Hofer, A. R. and Knemeyer, A. M. (2009), "Controlling for logistics complexity: scale development and validation", International Journal of Logistics Management, Vol. 20 No. 2, pp. 187-200.
Inger, R., Braithwaite, A. and Christopher, M. (1995), "Creating a manufacturing environment that is in harmony with the market--the 'how' of supply chain management", Production Planning & Control, Vol. 6 No. 3, pp. 246-258.
Johnson, P. F. and Michiel, R. L. (2001), "The supply organizational structure dilemma", Journal of Supply Chain Management, Vol. 37 No. 3, pp. 4-12.
Kilpatrick, J. and Factor, R. (2000), "Logistics in Canada survey: tracking year 2000 supply chain issues and trends", Materials Management and Distribution, Vol. 45 No. 1, pp. 16-20.
La Londe, B. J. (2003), "Three Problems that Linger", Supply Chain Management Review, Vol. 7 No. 2, pp. 7-9.
La Londe, B. J. and Masters, J. M. (1994), "Emerging logistics strategies: Blueprints for the next century", International Journal of Physical Distribution & Logistics Management, Vol. 24 No. 7, pp. 35-47.
Lambert, D. M. and Cooper, M. C. (2000), "Issues in Supply Chain Management", Industrial Marketing Management, Vol. 29 No. 1, pp. 65-83.
Lambert, D. M., Cooper, M. C. and Pagh, J. D. (1998), "Supply chain management: Implementation issues and research opportunities", International Journal of Logistics Management, Vol. 9 No. 2, pp. 1-19.
Lewis, M. W. (1998), "Iterative triangulation: a theory development process using existing case studies", Journal of Operations Management, Vol. 16 No. 4, pp. 455-469.
Mentzer, J. T., Foggin, J. H. and Golicic, S. L. (2000), "Collaboration: the enablers, impediments, and benefits", Supply Chain Management Review, Vol. 4 No. 4, pp. 52-58.
Milligan, B. (1999), "Despite attempts to break them, functional silos live on", Purchasing, Vol. 127 No. 7, pp. 24-27.
Moberg, C. R., Speh, T. W. and Freese, T. L. (2003), "SCM: Making the vision a reality", Supply Chain Management Review, Vol. 7 No. 5, pp. 34-40.
Monczka, R. M. and Morgan, J. (1997), "What's wrong with supply chain management?", Purchasing, Vol. 122 No. 1, pp. 69-73.
Monczka, R. M. and Morgan, J. (1998), "Questions you need to ask about your supply chain", Purchasing, Vol. 124 No. 8, pp. 42-46.
Morgan, J. (1997), "Integrated supply chains: how to make them work!", Purchasing, Vol. 122 No. 8, pp. 32-37.
Neuman, J. and Samuels, C. (1996), "Supply chain integration: vision or reality?", Supply Chain Management: An International Review, Vol. 1 No. 2, pp. 7-10.
Notteboom, T. E. and Rodrigue, J.-P. (2005), "Port regionalization: towards a new phase in port development", Maritime Policy & Management, Vol. 32 No. 3, pp. 297-313.

Pagell, M. (2004), "Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics", Journal of Operations Management, Vol. 22 No. 5, pp. 459-487.
Panayides, P. M. (2006), "Maritime Logistics and Global Supply Chains: Towards a Research Agenda", Maritime Economics & Logistics, Vol. 8 No. 2, pp. 3-18.
Park, S. H. and Ungson, G. (2001), "Interfirm rivalry and managerial complexity: A conceptual framework of alliance failure", Organization Science, Vol. 12 No. 1, pp. 37-53.
Pitera, T. (2000), "Going Through Walls", Inbound Logistics, Vol. 6 No. 1 (January), pp. 145-164.
Poirier, C. (1999), Advanced Supply Chain Management, Berrett-koehler Publishers, San Francisco, CA.
Quinn, F. J. (1997), "Team up for supply-chain success", Logistics Management, Vol. 36 No. 10, pp. 39-41.
Quinn, F. J. (1999), "Cooperation and collaboration: The keys to supply chain success", Logistics Management and Distribution Report, Vol. 38 No. 2, pp. 35.
Richey, R. G., Chen, H., Upreti, R., Fawcett, S. E. and Adams, F. G. (2009), "The moderating role of barriers on the relationship between drivers to supply chain integration and firm performance", International Journal of Physical Distribution & Logistics Management, Vol. 39 No. 10, pp. 826-840.
Robert, M. M. and Jim, M. (1998), "Questions you need to ask about your supply chain", Purchasing, Vol. 124 No. 8, pp. 42.
Scandura, T. A. and Williams, E. A. (2000), "Research Methodology in Management: Current Practices, Trends, and Implications for Future Research", The Academy of Management Journal, Vol. 43 No. 6, pp. 1248-1264.
Sheridan, J. H. (1999), "Managing the chain", Industry Week, Vol. 248 No. 16 (September), pp. 50-66.
Skjoett-Larsen, T. (2000), "Third party logistics - from an interorganizational point of view", International Journal of Physical Distribution & Logistics Management, Vol. 30 No. 2, pp. 112-127.
Smagalla, D. (2004), "Supply-Chain Culture Clash", MIT Sloan Management Review, Vol. 46 No. 1, pp. 6.
Stevens, G. C. (1989), "Integrating the Supply Chain", International Journal of Physical Distribution & Logistics Management, Vol. 19 No. 8, pp. 3-8.
Tyndall, G. R., Gopal, C., Partsch, W. and Kamauff, J. (1998), Supercharging Supply Chains, John Wiley & Sons, Inc., New York, NY.
Van Hoekm, R. I., Commandeur, H. R. and Vos, B. (1998), "Reconfiguring Logistics Systems Through Postponement Strategies", Journal of Business Logistics, Vol. 19 No. 1, pp. 33-54.
Yin, R. K. (2003), case study research : design and methods, Thousand Oaks : Sage Publications, New York.
Zaheer, A., McEvily, B. and Perrone, V. (1998), "The Strategic Value of Buyer-Supplier Relationships", International Journal of Purchasing and Materials Management Vol. 34 No. 3, pp. 20-26.

A STUDY ON THE IMPROVEMENT OF TRUCK TRANSPORTATION EFFICIENCY FOR GREEN LOGISTICS - COOPERATIVE APPROACHES BETWEEN TRANSPORTATION COMPANIES AND SHIPPERS -

Tomokazu Yoshifuji[†1], *Minoru Saito*[†2]
†1 Nittsu Research Institute and Consulting, Inc.
1-9-3, Higashi-Shimbashi, Minato-Ku, Tokyo, 105-8322, Japan
(Tel: 03-6251-3324, E-mail: yoshifujit@soken.nittsu.co.jp)
†2 Faculty of Economics at Kanagawa University
3-27-1, Rokukaku-Bashi, Kanagawa-Ku, Yokohama-Shi, Kanagawa, 221-8686, Japan
(Tel: 045-481-5661, E-mail: saitom01@kanagawa-u.ac.jp)

ABSTRACT

The purpose of this paper is to make clear the real situation of inefficient truck transportation due to irrational requests from shippers and propose practical measures for improving the efficiency of truck transportation. Firstly, we carried out a questionnaire survey to find the real situation of logistics practices between trucking companies and shippers related to the condition of transactions. By analysing the questionnaire survey, several transportation problems related to the condition of transactions will become clear. Secondly, by analysing case studies, we will clarify that the partnership between trucking companies and their shippers play a significant role in achieving more eco-friendly truck transportation. Finally we propose the new paradigm in how should trucking companies and their shippers contribute for green logistics.

Keywords: Supply Chain Management, Supply chain inter-firm networks and collaboration, Environmental Sustainability and Green Logistics

Background and Purpose

While Carbon-dioxide (CO2) emissions in transportation section in Japan became a decrease in 4.1% compared with the previous year in 2008, The CO2 exhaust increases by 8.0% compared with 1990 (Figure 1). Especially, trucking industry is accounting for 54% of the freight traffic volume (53% of freight ton kilometers) of my entire country. The leading part of the freight transport in distribution is trucking industry. In recent years, the improvement of truck transportation efficiency has been increasingly important from the viewpoint of green logistics. The Japanese government requires trucking companies and shippers to make more efforts to decrease CO_2 emissions in their logistics processes. Although many trucking companies have introduced eco-friendly measures such as utilizing more fuel-efficient trucks and practicing eco-driving, it is not enough to achieve the goal. It is necessary to improve truck transportation efficiency much more and eventually reduce the environmental burden in logistics by implementing new different methods.

It is very important to find what kinds of elements in logistics actually retard the improvement of truck transportation efficiency. The condition of transactions in logistics between trucking companies and shippers has had significant effects on truck transportation efficiency. Most shippers in Japan strongly require a very strict shipping deadline, extremely frequent delivery and very small lot size transportation as a condition to do business. These severe conditions hurt truck transportation efficiency. In order to achieve a more eco-friendly truck transportation system, we need to focus on the significance of the conditions of transactions in logistics.

The purpose of this study is firstly to find the real situations seen in transactions in logistics and how it really gives negative effects on truck transportation efficiency. Secondly, we will propose some good practices in a case study where trucking companies and their shippers succeeded in increasing truck transportation efficiency by improving the condition of the transactions in logistics.

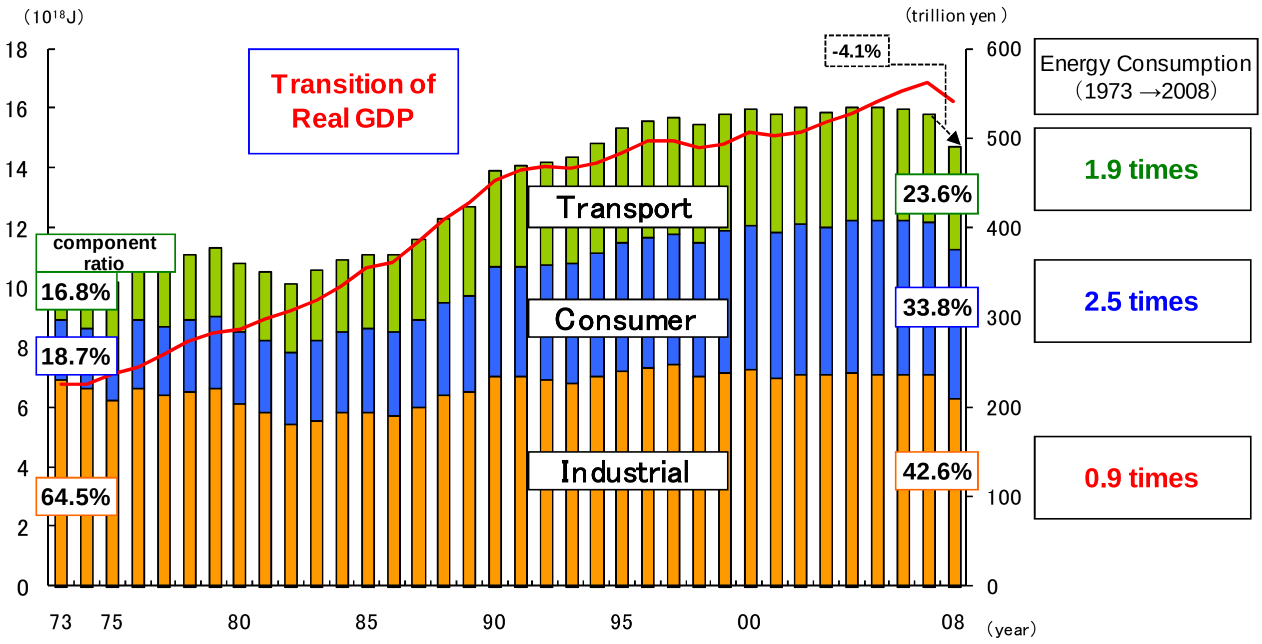


Figure 1 : Transition of Final Energy Consumption and Real GDP
(Ref : "Statistics of Comprehensive Energy 2011",
Agency for Natural Resources and Energy, Japan)

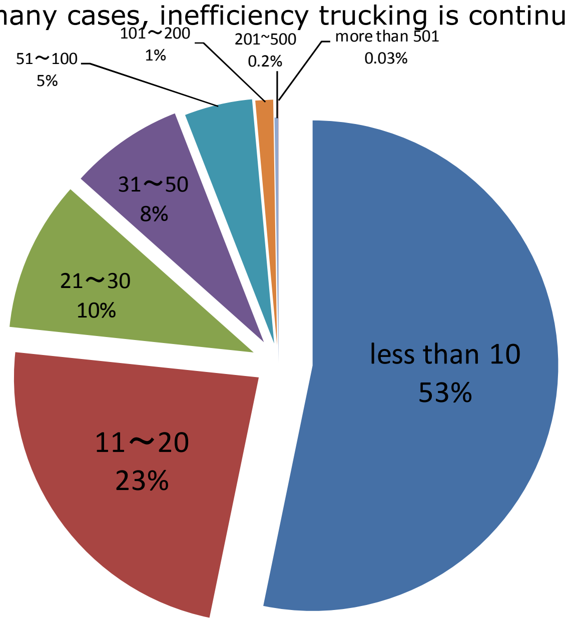
State of Trucking Industry (Japan)
We sort out the state of trucking industry in Japan.

1. Japanese Government's Request
   In Japan, the "Revision Law Concerning Rational Use of Energy" requests transportation and shipper companies of goods to make efforts to decrease CO2 emissions in their logistics processes. However, many of the trucking companies cannot increase their workload easily. Therefore, many trucking companies have introduced eco-friendly measures such as utilizing more fuel-efficient trucks and practicing eco-driving (that are easy to try) because most of them are small or medium-sized companies in Japan.

2. Relationship between Subcontractors and Contract Companies
   The overwhelming majority are small sub contractors and sub-subcontractors of construction. These companies own less than 20 trucks account for 99.0% of the total. (Figure 2). The shipper company has domination to the small trucking companies in business dealings. And, the trucking companies lack the bargaining power compared with the shipper. As a result, relatively, they cannot help undertaking the transport business under a severe condition.

3. Relationship between Subcontractors and Sub-Subcontractors
   The big trucking companies subcontract actual transportation to the small trucking companies in many cases for labor management, asset cost reduction, and accident risk reduction. In addition, under the current situation of rising oil prices and demand for excessive services, it has been more difficult for them to make enough

profit and to also make efforts to reduce CO2 emissions "single-handedly". Actually, in many cases, inefficiency trucking is continuing.



Number of Vehicles	Number of Companies
less than 10	30,581
11～20	13,464
21～30	5,707
31～50	4,310
51～100	2,573
101～200	671
201～500	132
more than 501	19
Total	57,457

Figure 2 : Number of Trucking Companies by Number of Vehicles Owned
(Ref : "Statistics of Automobiles" (briefing paper),
Ministry of Land, Infrastructure, Transport and Tourism, Japan)

Questionnaire Survey

Firstly, we carried out a wide-ranging questionnaire survey to find the real situation of logistics practices between trucking companies and shippers related to the condition of transactions. In this study, the subjects of the questionnaire survey are 5,002 trucking companies and 864 large-scale shippers (Table 1). By analysing the questionnaire survey, several transportation problems related to the condition of transactions will become clear. Number of respondent by amount of capital and labor is shown as Figure 3 and 4.

Table 1 : Subjects of the Questionnaire Survey

	Surveyed Number of Companies	Respondent	Response Rate
	A	B	B / A
Trucking Companies (*1)	4,543	1,227	27.0%
Shippers (*2)	858	226	26.3%

*1
Trucking Business Other than Special Joint Loading

*2
Specified Shippers by "Energy Saving Act"

1. Extremely Frequent Delivery and strict deadline

First of all, we asked whether to be trying to improve "loading ratio" for efficient transportation. Figure 5 shows the result. The companies that answered "Executing it in most cases" account 23.9% and the companies of the remainder answer "Partial doing or not doing the effort for the improvement of the loading ratio". And see details, "Not executing it though we want to try" is 29.3%. "Not understanding how execute" is 6.1%. These companies are more than "Executing it in most cases". As seen above, we clarified the trucking companies think the improvement of loading ratio was difficult though it is necessary for more efficiency.

Then, what is the reason why the loading ratio of the track cannot be improved? Figure 6 shows the answer to this question. Points of focus are "Shipper's request about frequent delivery for reducing stock" (34.8%) and "To evade the loss of sales opportunities" (18.5%). As a result, we clarified "Extremely Frequent Delivery" is a big factor to obstruct the improvement for loading ratio of the tracks. An interesting point is a delivery frequency to the same delivery destination in relation to the multi frequency delivery. "Delivered to the same facilities and the store two or more times in one day" account for 35.2% of all trucking companies (Figure 7). In addition, delivery frequency is as follows. "Three times" is 39.8%, "more than four times" is 32.5%. This result is best example of actual condition about "Extremely Frequent Delivery". Why is "Extremely Frequent Delivery" continuing? It was "Relation to the manufacturing process" is biggest reason. It is because of "Just-In-Time" transportation for manufacturer. Additionally, there are "shortening of lead time", "Request for reducing stock", and "Immediate shipment". It is continuing because the main convenience for arrival (or shipper) of goods was prioritized.

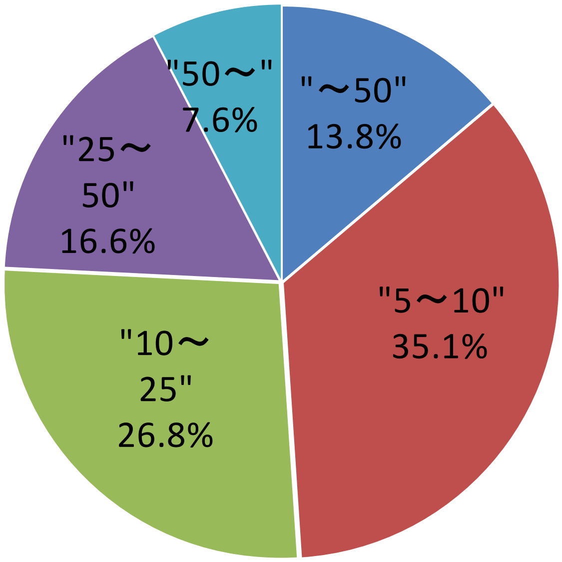


Figure 3 : Number of respondent by amount of capital
(Million Yen) (n=1181)

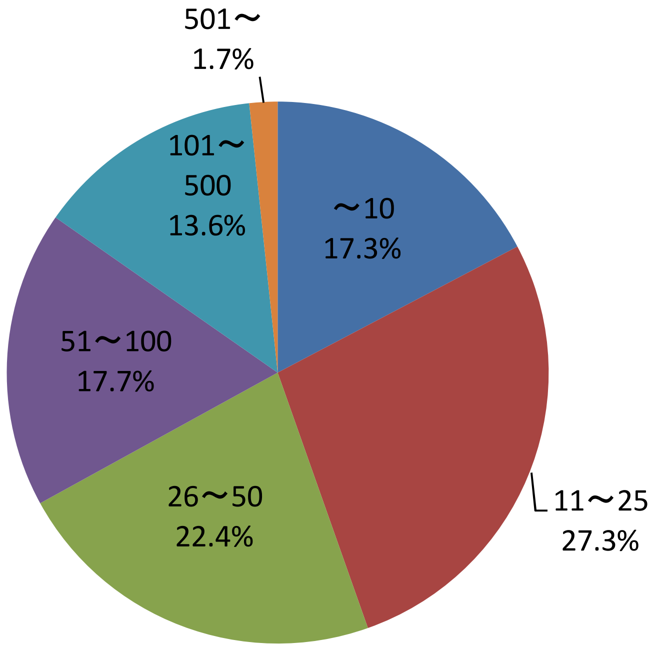


Figure 4 : Number of respondent by amount of labor
(people) (n=1191)

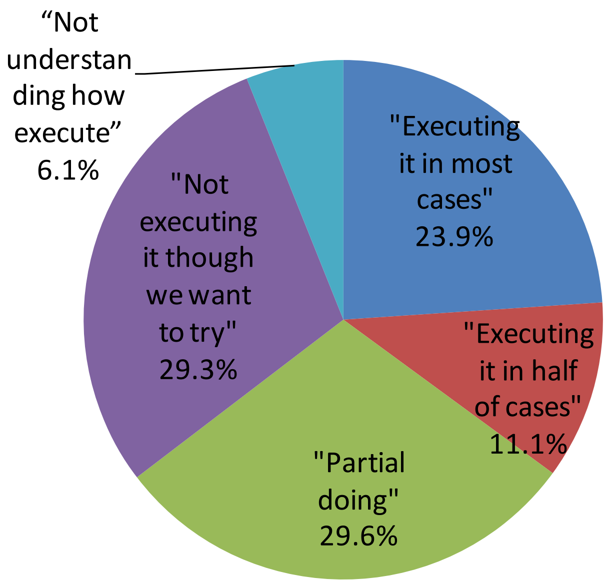


Figure 5 : Whether to be Trying to Improve “Loading Ratio” for Efficient Transportation (n=1187)

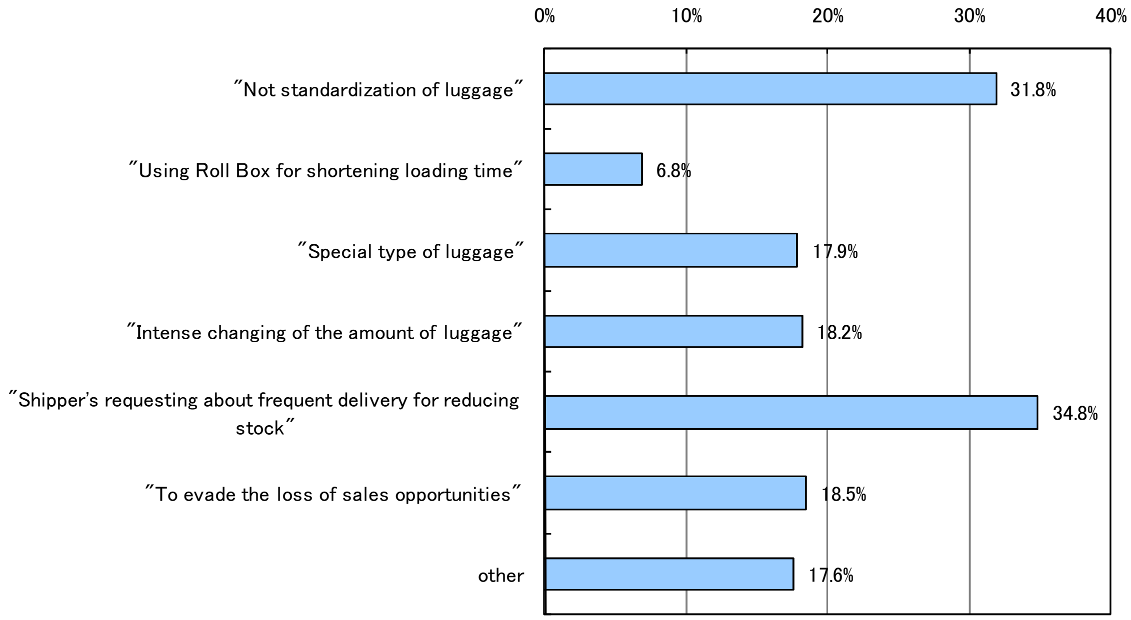


Figure 6 : Reason Why the Loading Ratio of the Track Cannot be Improved (n=336)

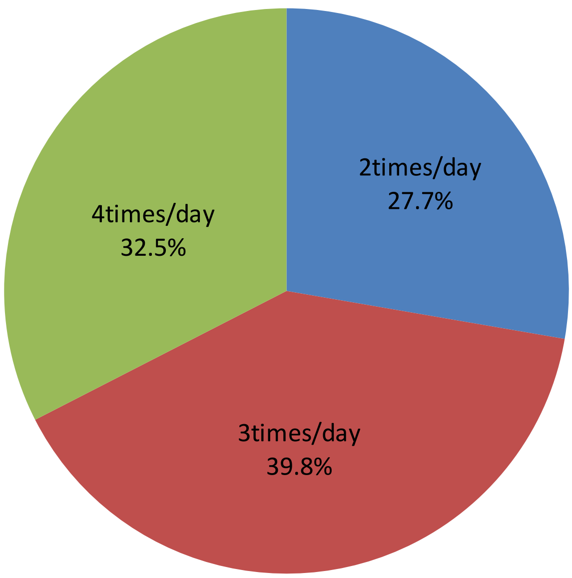


Figure 7 : How Many Times Deliver to Delivered to the Same Facilities and the Store (n=166)

2. Continuous occurring of waiting time

Waiting time in collection and delivery is shown in Figure 8. Frequency of waiting in collection and delivery is shown in Figure 7. This situation will not turn any profit on transportation. And It is continuing because the main convenience for arrival (or shipper) of goods was prioritized. Frequency of waiting in collection and delivery is shown in Figure 9.

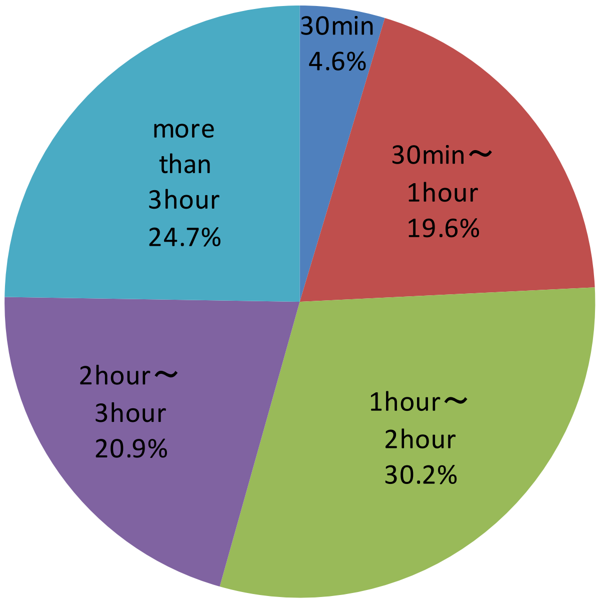


Figure 8 : Waiting Time in Collection and Delivery
(n=388)

As seen from the above We clarified these practices certainly harm both the improvement of truck transportation efficiency and the reduction of CO2 emission by trucks.

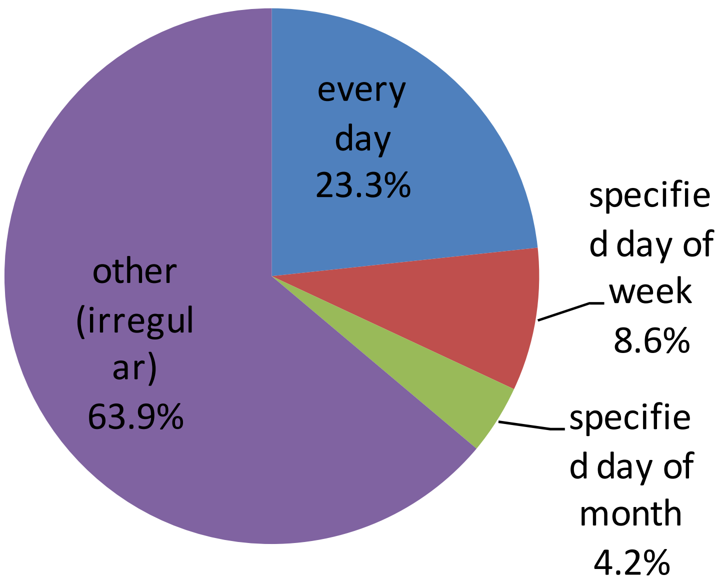


Figure 9 : Frequency of Waiting Time
in Collection and Delivery
(n=382)

Hearing Survey

Secondly, we carried out a hearing survey to trucking companies in order to find good practices that are able to improve the inefficiency of truck transportation and actually reduce CO2 emissions (Table 2). Especially we focussed what kind of intelligence sharing is necessary between transportation company and shipper company. From result of analysing the case studies, we propose that the partnership between trucking companies and their shippers (such as Figure 10). It makes each companies play a significant role in achieving more eco-friendly truck transportation.

Table 2 : Rough Items of Hearing Survey

Reviewed conditions of trucking
Purpose and aim of reviewing
Details to review of conditions of trucking
Proposer (who started).
Coordinator of shippers or consumers (for adjustment)
Period until full executing
Effect of reduction of CO2 emissions
Effect of reduction of transportation cost
What kind of intelligence sharing is necessary between Transportation Company and Shipper Company

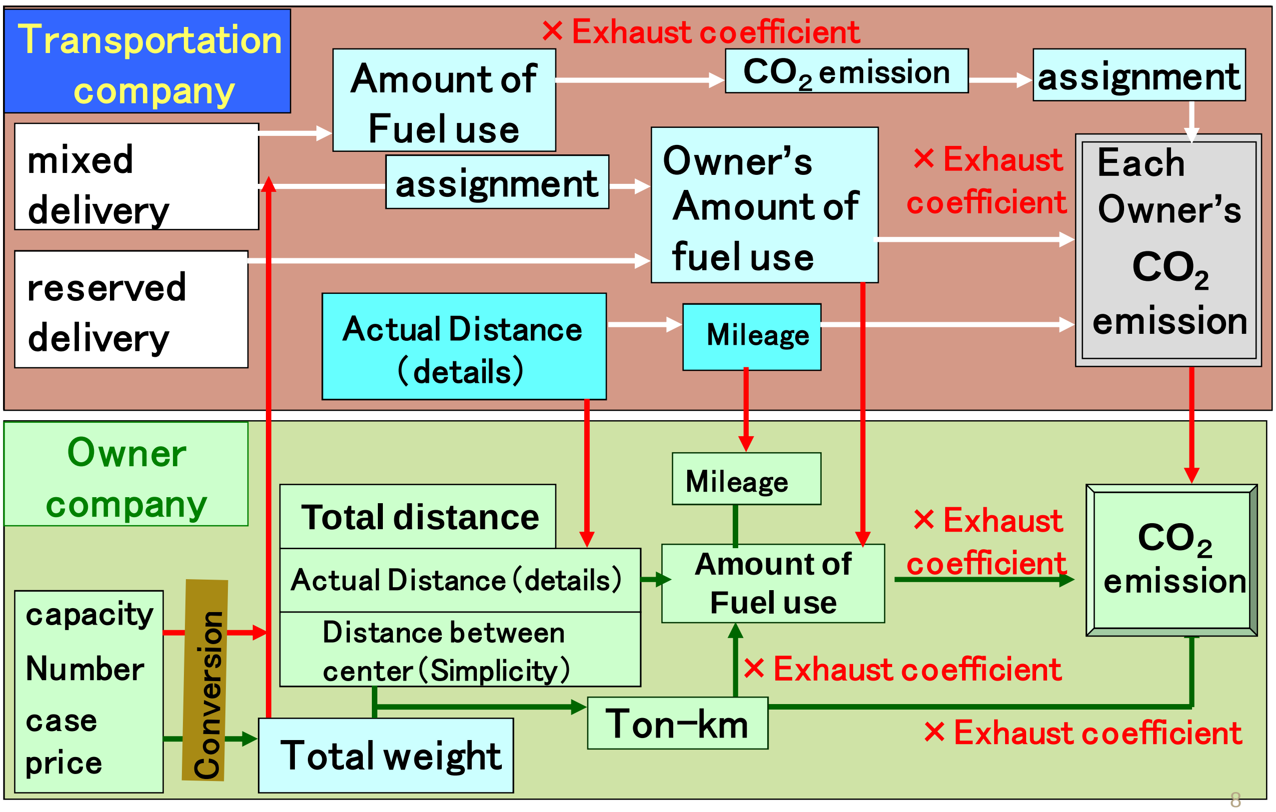


Figure 10 : Intelligence Sharing
between Transportation Company and Shipper Company

Findings from Questionnaire and Hearing Survey
There are actually a lot of negative practices in logistics such as very strict shipping deadlines, extremely frequent delivery and very small lot size. These practices certainly harm both the improvement of truck transportation efficiency and the reduction of CO2 emission by trucks. On the contrary, stopping these negative practices in logistics and adapting more rational practises by negotiating successfully between trucking companies and their shippers significantly contribute to green logistics.

There are quite a few studies that focus on the importance of the condition of transactions from the viewpoint of green logistics. This study will propose a new possibility for progress in green logistics.

Conclusions
In this paper, we pointed out most of Japanese companies such as manufacturers and retailers, which need "Just-In-Time" delivery, depend heavily on the truck transportation services provided by trucking companies and however trucking companies are facing a difficult problem of inefficiency of their truck transportation.

The main reason for the efficiency is strongly related to their shippers' irrational transportation requests.

A typical irrational request from shippers is to demand frequent deliveries to the same consignee in a day, which deteriorate the loading rate of truck fleets and eventually make truck transportation inefficient.

We clarified the real situation of inefficient truck transportation due to irrational requests from shippers and propose practical measures for improving the efficiency of truck transportation.

REFERENCES

[1] Tomokazu Yoshifuji, Masayuki Goto, Tetsuo Yamada, Tadayuki Masui (2008) "Information Modeling to Calculate CO2 Emissions Caused by Distribution and Its Allocations", 13th ISL, 546-554

[2] Takahashi Yoji (2005) "An Evaluation Study on the Social Experiment of Modal Shift to Reduce Carbon Dioxide Emission", Journal of the Eastern Asia Society for Transportation Studies 6(0), 2881-2893

[3] Sundarakani B, Souza, R, Goh M, Cai S (2008) "Measuring Carbon Footprints Across the Supply Chain", 13th ISL, 555-562

[4] Agency for Natural Resources and Energy (Japan) (2011) "Statistics of Comprehensive Energy 2011", 211-1

[5] Japan Institute of Logistics Systems (JILS) (2003) "Manual for introducing the environmental logistics management system", 29

[6] Japan Institute of Logistics System-Logistics Environmental Management System (2008) "Green Logistics Guide", in Japan

[7] Ministry of Economy, Trade and Industry (2008) "Guidance of data exchange related to amount of CO2 exhaust", in Japan

SECTION 11 – SUPPLY CHAIN SERVICES AND EMERGING MARKETS

CLASHING LOGICS: A TEACHING CASE ON CHALLENGES IN INDUSTRIAL SERVICE MARKETING CHANNELS

Danilo Brozović[1], Fredrik Nordin[1], Christian Kowalkowski[2], Mats Vilgon[3]
[1]Stockholm University, [2]Linköping University, [3]Stockholm School of Economics

ABSTRACT

Purpose:
The purpose of this paper is to describe a teaching case study which can be used as an exercise to increase students' knowledge of overcoming challenges with new channel actors in industrial service contexts.

Design/methodology/approach:
The paper is designed as a teaching case study that focuses on challenges of a Finish provider of high quality industrial mechanical and electromechanical products, services, and solutions, caused by a channel entrance of a new actor due to the customer outsorcing the activities because of emergency cost savings.

Findings:
The relevance of management strategies that reduce the distance from customers in industrial service marketing channels is emphasized. At the end of the case text, questions for discussion are provided.

Practical implications:
The article presents a practical and straightforward approach for instructors to explain the marketing channel concept and challenges related to entrance of new actors caused by customer outsorcing in industrial service contexts. The findings of the case also have tangible implications for industrial companies who are struggling with the challenges of handling service intermediaries in their marketing channels.

Originality/value:
There is a scarcity of published teaching case studies the specific topic. This work improves the understanding of intermediary challenges in service marketing channels of industrial companies, caused by outsorcing and the change of customer logic.

Keywords:
Industrial services, intermediaries, channels, teaching case, outsorcing, servitization

BACKGROUND

SKF is a leading global supplier of products, solutions and services within rolling bearings, seals, mechatronics, services and lubrication systems. Services include technical support, maintenance services, condition monitoring and customer training. SKF was founded in Gothenburg, Sweden, and in 2010, the company had net sales of €6 billion (US$9 billion) and approximately 40,000 employees worldwide. SKF technology can be found in very diverse applications, from energy wind farms, offshore oil rigs, steel and paper mills, high-speed trains to washing machines, cars and motorcycles.

Although SKF is the global leader in bearings, it does not want to be perceived as a product-centric manufacturing firm. Instead, the company puts great emphasis on a customer centric approach aimed at delivering superior customer value through its offerings, which is increasing through services and integrated solutions (see appendix). Mr Torvik, SKF's Business Development Manager in the Service Division Area Northern

Europe, who has long been convinced of the potential of services for the company and its customers, says:

> *"'Servitisation' is here to stay. We have seen in many industries that manufacturing companies, proactively or reactively, are extending their product offerings with services. Commoditisation and competition from low-cost countries decrease our margins for traditional product sales. However, servitisation provides a key opportunity to leverage our knowledge engineering expertise through services and solutions to work more strategically with our clients, helping them to become more profitable by delivering superior customer value."*

The market for services typically counteracts the cyclicality of manufacturing operations. This became evident in the recent financial crisis 2008/09 when SKF's Service division performed significantly better than the two product divisions. SKF also puts major emphasis on training its salespeople of value selling rather than technical product selling. As Mrs. Hultsson, a Business Process Developer at SKF, responsible for sales processes, explains, selling services is challenging:

> *"A new kind of seller is needed. The ones we have are often too narrow-minded and product oriented. In particular, the sales representatives at out resellers are typically very reactive. We are trying to educate them, but it is not easy."*

The company is working systematically to understand and communicate the value of their offerings to customers. Since the company has made a systematic and methodical effort to document the actual savings and increased productivity, it has become knowledgeable about how its offerings deliver superior value to customers and how the value delivered varies across different customer segments. SKF leverages the knowledge it gains to bundle different value attributes to each customer segment (or large customer) and offer customised solutions.

"The market power is indeed in the services", thought Mr. Torvik, flying home from Finland after a promising meeting with Empower, a young and vigorous company that describes itself as a multinational service group delivering construction, maintenance and professional services within energy, telecom and industry sectors. He was thinking of initiating a sort of cooperation with Empower in the Finnish market, characterized by heavy outsorcing [1]. But now it was time to continue working on the improvements within the SKF's Solution Factory [2].

MANAGEMENT CONCERNS

Mr. Torvik's next workday started busy as usual, he was answering emails and telephone calls from early mornings. But the email he read that morning had made him worried; Mr. Arinen, the Managing Director of SKF in Finland, was telling Mr. Torvik to call him the minute he would reach the office. The email was rather short, but Mr. Torvik thought he knew what it was about. Something was going wrong in their Finnish market. He remembered the long conversations he and Mr. Arinen had had regarding the changing situation in Finland. The Finnish subsidiary of SKF has approximately 150 employees. Its customers are primarily from the process industry, such as paper and pulp companies, and OEMs. The turnover 2009 was €30 million.

Mr. Torvik hurriedly arrived at the main office of SKF, an imposing brick building from the mid-sixties located closely to the center of Gothenburg. He had not stopped thinking about the email he had received from Mr. Arinen. SKF's Finnish market had for some time now been characterized by stability, but the financial crisis had caused turbulence: industrial companies were increasingly transferring activities such as production, operation, and maintenance, to specialized actors providing acceptable solutions at a lower cost. SKF had successfully competed with its philosophy of delivering superior customer value and long term productivity improvements as opposed to just products and services of low cost, but the situation was changing. The crisis had struck hard against many client firms in Finland.

"Hello, Antti, it is me," said Mr. Torvik. The view from his office was magnificent; Gothenburg spreading itself in all directions. Mr. Torvik knew that the view from Mr. Arinen's office was not equally splendid.

"Tomas, we have a problem," said Mr. Arinen without greeting his colleague. He then explained that its largest Finnish client in the pulp and paper segment has decided to outsource all its service activities, service employees and maintenance to a provider of a broad range of inexpensive services. The outsourcing agreement was of a fixed-price type and would last for four years, promising 20% lower price. The new agreement meant that SKF had just lost a significant share of its Finnish market within the segment as an indirect result of the crisis. And the inexpensive service provider worked in a very simple manner: taking over the client's maintenance personnel, resigning a part of it and efficiently using the remaining workforce, and at the same time purchasing the cheapest available components.

"Tomas," replied his Finnish colleague, "the client is fully aware of the advantages that our products and accompanying solutions bring in the long term, but as they express it, there is no long term if they do not survive the short term. The crisis has struck pretty hard. But," said Mr. Arinen, "I send you an idea we have come up with. Mrs. Hultsson, our key account manager, and I have devised a possible solution to the problem. The contract we intend to offer to the customer is based on the three cycles of three years, where we basically strip the initial solution in the first three year cycle. We unbundle the offer from the advanced services to be able to compete with price, and later as the crisis flattens, we add more and more accompanying services and reach the initial contract in the last three year cycle." Mr. Arinen continued: "Think about it, but please, Tomas, reply latest this afternoon. The key account manager visits the customer tomorrow, and we must have your blessing."

Mr. Torvik nodded. "You will have my answer by the end of the day." He sighed. Just as he had suspected, the news from Finland had not been good. He had been receiving reports about smaller clients opting for outsourcing companies offering cost savings, despite the lower quality of both products and services, and he knew about this client was coping with severe financial problems caused by the present crisis. He had not expected, though, that SKF would lose this important client as well, he had been convinced that the philosophy of long term and customer value would prevail. He realized that a third of the customers in the segment obviously had decided to change its attitude and the philosophy of work. For the Finish subsidiary of SKF, these changes would imply dramatic consequences.

The severity of the financial problems had made the focus on costs inevitable and eliminated the interest for more advanced services. The outsourcing also meant that the previous strategically important interface with senior-level executives at the customer would be transferred to the more cost-oriented outsourcing companies. SKF would become a subcontractor to these companies, which would not be a desirable position.

The proposition that he received was clever, and Mr. Torvik was very much able to see its benefits. But he was also very much able to see its drawbacks: it clearly stated that the customer was not obliged to continue dealing with SKF after the first three-year-cycle. What would happen if the customer did not want to prolong the contract? Would SKF then be perceived as a low cost company that delivers short-term cost savings? What effects would that have on their reputation as a provider of customer value? Would the rest of the market eventually equalize SKF's bearings and seals with cheap copies of inferior quality produced who knows where? A new idea was gradually starting to build in Mr. Torvik's head; the possible alternative of aligning with a partner to be able to better address customers' situation without risking drawbacks such as a deteriorating reputation. Would a company such as Empower, for instance, be interested in joining forces to address the new situation? They were a much smaller and very flexible specialised service company that perhaps could supplement SKF by handling lower margin business deals? Partnering with them would most likely work since they already had good experiences from collaborating, though on a smaller scale.

DISCUSSION QUESTIONS

1. *What strategic options does SKF have for coping with the new situation where the customer deserts higher-value services for the sake of short-time savings? What is required from SKF in order to pursue each of the options available and manage the situation? Which options are more appropriate?*

2. *Choose two of the options above that you consider being the most appropriate for SKF to pursue. Present advantages and disadvantages, and develop SWOT analysis for the two options. Argument precisely why these two options are best for SKF in solving the strategic issue described previously.*

APPENDIX:

SKF was from early on aware of the key strategy present in the modern industrial business: the market power is in the services that provide value for the customer. As Vandermerwe and Rada [3] predicted, SKF was one of the winning companies because it understood that customers want specific solution systems that meet their demands, consisting of product-service components and basing the systems on results [4]. This is what SKF's performance-based contracts and flexible modular services are all about. Forget about "just bearings": think solutions instead.

The services included in the SKF portfolio vary, but its pride is the SKF Asset Management Services [5], a complete array of strategic and tactical asset management services worldwide. SKF begins with a proven process to identify plant improvement opportunities and help develop solutions. Its consultants work to understand a client's business goals, application challenges and plant culture to create a road map for improving reliability. Together with the client, SKF develops strategies and programs to achieve bottom-line results, and through SKF Client Needs Analysis [6] provides answers to such questions as: How and where can the client improve plant performance? How should the client better align its plant with industry benchmarks? How does the client assure continual improvement in the plant's maintenance process?

Not to mention SKF Condition Monitoring, Remote Monitoring and Diagnosis, Integrated Maintenance Solutions, and many other services and solutions that SKF provides. And the best benefit is that a client can tailor a solution based on its own preference. The client does not want remote monitoring, but is in the need for mechanical maintenance? No problem.

REFERENCES:

[1] Outsorcing: A Happy Fix, http://www.economist.com/node/13059821?story_id=13059821, retrieved 2011-04-18.

[2] SKF Media Library, http://www.skf.com/portal/skf/home/library?contentId=871232&lang=en&wmode=asset&assetId=0901d196800962c8, retrieved 2011-04-18.

[4] Vandermerwe, S. and Rada, J. (1988), "Servitization of Business: Adding Value by Adding Services", European Management Journal, Vol. 6 No. 4, pp. 314-324.

[5] Turunen, T. and Toivonen, M. (2011), "Organizing customer-oriented service business in manufacturing", Operations Management Research, pp. 475-489.

[6] SKF Asset Management Services,
http://www.skf.com/portal/skf/home/services?contentId=447465&lang=en,
retrieved 2011-04-18.

[7] SKF Client Needs Analysis,
http://www.skf.com/portal/skf/home/services?contentId=447465&lang=en,
retrieved 2011-04-18

MEASURING RETAIL NETWORK EFFICIENCY THROUGH DATA ENVELOPMENT ANALYSIS

Kwok Hung Lau, Prem Chhetri, Booi Kam, Brian Corbitt and France Cheong

School of Business IT and Logistics
RMIT University
Melbourne
Australia 3000

ABSTRACT
Using a major retailer in Australia as a case study, this paper applies the Data Envelopment Analysis (DEA) methodology to measure the performance of six stores run by the retailer in its distribution network. Cost figures and revenues for individual stores are used as variables in the analysis. Results show that out of the six stores investigated three are relatively less efficient in performance. Together with other analyses such as customer segmentation and spatial distribution of demand, it is apparent that overall efficiency of the retail network can be improved by either closing the less efficient stores or merging them with the others in the same service areas so as to streamline the network. Such rationalisation will help aggregate demand and improve vehicle utilisation with minor impact on current level of customer service.

INTRODUCTION
Efficiency and responsiveness can be regarded as two primary goals in supply chain management (SCM) (Chopra & Meindl 2010). To achieve these objectives, waste elimination and flexibility enhancement are the keys. They help reduce operating costs and enforce continuous improvement thereby increase overall efficiency and responsiveness. In retail industry, the number of distribution outlets or front stores is directly related to the attainment of these objectives. While having more front stores implies a greater degree of responsiveness or an increased level of customer service, it may also lead to excess inventory, higher facility and operating costs, and lower asset utilisation. A balance has to be struck so as to gain higher efficiency through economies of scale while maintaining a competitive level of responsiveness.

Conventionally, network optimisation in SCM is achieved through mathematical programming (Chopra & Meindl 2010). Quantifiable variables are used as input parameters to set up objective function as well as constraints. The greater the complexity of the network in terms of product variety, storage facilities, distribution outlets, and markets, the more complicated the problem formulation will be. Therefore, it is not uncommon that sophisticated software is used for data analysis to generate the required input parameters as well as the solution. The task can be very time-consuming and tedious and requires special expertise to accomplish. This can prove to be formidable to store managers particularly if network optimisation is regarded as an ongoing exercise for continuous improvement. Therefore, simpler tools that are easy to employ and require lesser amount of input data have to be sought. Owing to its simplicity of use and flexibility in data requirement, Data Envelopment Analysis (DEA) has become a popular tool in the last two decades for performance measurement and benchmarking (see for example Bessent et al., 1983; Deville, 2009; Donthu & Yoo, 1998; Halim, 2010; Ross & Droge, 2002). However, despite widespread application of the methodology in many disciplines, the use of DEA in retail network rationalisation has not been fully investigated.

This research uses a major retailer in Australia as a case study and applies the DEA methodology to measure the performance of six stores run by the retailer in its distribution network. Cost figures and revenues for individual stores are used as variables in the analysis. Through DEA and other investigations, this study aims at demonstrating that retail network analysis and rationalisation can be done in a simpler manner without resorting to complex mathematical programming. The process can be standardised to facilitate regular monitoring and benchmarking store performance for continuous improvement.

LITERATURE REVIEW

DEA is a non-parametric linear programming method (i.e., assumption of a particular functional form/shape for the efficiency frontier is not required) for comparing the productivity (or efficiency) of different decision making units (DMUs) based on multiple inputs and outputs. The approach was introduced by Charnes et al. (1978) based on the idea of Farrell (1957) and subsequently extended by Banker et al. (1984). The original formulation, known as the CCR model, assumes no significant relationship between scale of operations and efficiency, i.e., constant returns to scale (CRS). To accommodate the situations where there is relationship between scale of operations and efficiency, Banker et al. (1984) revise the formulation, known as the BCC model, and incorporate additional constraint to permit assessment of efficiency of DMUs characterized by variable returns to scale (VRS). Since then, the method has been widely applied in various fields, such as education (Bessent et al, 1983), pharmacy (Färe et al., 1992), marketing (Parsons 1990), insurance (Mahajan, 1991), banking (Charnes et al., 1990), manufacturing (Talluri et al., 1997), distribution (Ross & Droge, 2002), and retailing (Kamakura & Ratchford, 1996), for measurement of efficiency across DMUs and for benchmarking.

In essence, DEA uses the ratio of summations of weighted inputs and outputs of each DMU to produce a single measure of productivity. DMUs that have a ratio of 1 are considered as totally efficient given the required inputs and the produced outputs. They form a boundary or efficiency frontier representing all possible combinations of inputs and outputs with maximum efficiency. DMUs with a ratio smaller than 1 are less efficient relative to the most efficient units and are located inside the frontier. Since the weights for the input and output variables are computed to maximise the efficiency ratio of a DMU and then compared to that of the best performing DMUs, the ratio can be regarded as a relative efficiency benchmark against that of the best performer (or best practice) in a homogenous group (Halim, 2010).

While there are studies on performance assessment of retail outlets using DEA, the emphasis seems to have been placed more on supermarket chains. Many of these studies focus either on the performance of individual stores in the same chain (Barros & Alves, 2004; Ket & Chu, 2003; Korhonen & Syrjänen, 2004; Vaz et al., 2010) or comparison of performance between different chains (Athanassopoulos & Ballantine, 1995). For example, Korhonen and Syrjänen (2004) evaluated the performance of 25 stores of a supermarket chain in Finland. They used number of staff working hours and floor area of the supermarket store as inputs. The outputs were total sales and profit. Similarly, Athanassopoulos and Ballantine (1995) used DEA to compare the efficiency of supermarket chains in the United Kingdom. The input variables included capital employed, value of fixed assets, number of employees, number of outlets, and sales floor area. The output variables included total sales. Although DEA can be used to help re-allocating resources among different stores in a retail network (Beasley, 2003; Lozano & Villa, 2004), the use of the methodology to facilitate network rationalisation has not been fully attempted. Therefore, it is the aim of this study to fill this gap in the literature.

METHODOLOGY

This research used the distribution network of a major retailer in Australia as a case study. DEA was conducted to compare the relative efficiency of six major stores of the retailer in the eastern suburbs of Melbourne – the second largest city in Australia - with the aim to determining how that part of the retail network could be rationalised to enhance overall efficiency. Owing to the extreme competitiveness of the trade, the nature of business of the retailer cannot be disclosed for commercial confidentiality reason. The retailer is a long-established company which has been in the trade for more than 80 years. At present, it has almost 400 stores across Australia and New Zealand with over 3,000 employees. It serves its customers with a product range of over 175,000 items.

The 2009 cost and sales data were used in the analysis. A CCR model with CRS assumption (Charnes et al., 1978) was employed. The input variables used include equivalent number of vehicles deployed for delivery (assuming 100% utilisation) and total transport costs (including both weekday and weekend deliveries). Output variables include number of customers served, number of invoices delivered, i.e., orders filled, and total value of invoices, i.e., total revenue. All values are calculated on an annual basis. The equivalent number of vehicles deployed for delivery is calculated by multiplying the number of vehicles stationed at each store with the average vehicle utilisation rate of the vehicle fleet at the store. This composite variable reflects more accurately the actual resources deployed to deliver goods to customers. The use of it is considered more comprehensive than taking either of the two variables alone or both of them together as inputs.

As the calculated efficiency may vary with the set of input and output variables used in the analysis, various combinations of the five variables used as input and output are tested to determine if there is any consistent pattern in the outcome. Table 1 shows the values of the input and the output variables in the study. Again for reason of commercial confidentiality, values of the variables are all expressed in percentage. Nonetheless, the outcome of the analysis is the same as when absolute numbers are used.

Table 1 Variables used in the analysis

	Input		**Output**		
Store	Equivalent Number of Vehicles Used for Delivery (A)	Total Transport Costs (B)	Number of Customers Served (X)	Number of Orders Filled (Y)	Total Revenue (Z)
1	9.5%	11.5%	8.8%	11.7%	11.5%
2	26.7%	24.8%	19.7%	25.9%	28.5%
3	12.2%	11.6%	11.5%	11.7%	10.5%
4	15.4%	15.8%	24.7%	15.2%	15.2%
5	17.9%	18.0%	18.6%	17.5%	17.4%
6	18.3%	18.3%	16.6%	18.0%	17.0%

FINDINGS AND DISCUSSION

Performance Efficiency

The performance efficiency scores of the six stores calculated using various combinations of inputs and outputs as shown in Table 1 are given in Table 2.

Table 2 Efficiency of stores evaluated upon different combinations of inputs and outputs

Combination	1	2	3	4	5	6
Input	A, B	A, B	A, B	B	B	B
Output	X, Y, Z	X, Z	Z	X, Y, Z	X, Z	Z
Store	Efficiency Score					
1	1.0000	1.0000	1.0000	0.9753	0.8838	0.8693
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.9883	0.8534	0.7960	0.9883	0.8534	0.7847
4	1.0000	1.0000	0.8844	1.0000	1.0000	0.8340
5	0.9636	0.9229	0.8783	0.9592	0.9065	0.8395
6	0.9632	0.8743	0.8422	0.9575	0.8559	0.8067

It can be see that in most of the cases, Stores 3 and 6 are relatively less efficient than the others. This is particularly so for Store 3. Out of the six combinations, four (Combinations 2, 3, 5, and 6) give more or less the same result. Likewise, Combinations 1 and 4 show a similar pattern with lower efficiency for almost all stores except Stores 2 and 4. Store 2 is the best performer regardless of the combination of input and output variables used. These findings suggest that the use of both input variables instead of a single input, such as Total Transport Costs, seems to be appropriate, as they represent different aspects of input. Similarly, the use of a single output, such as Total Revenue, does not seem to be adequate as it fails to reflect other performance measures, such as market coverage. However, the use of Number of Orders Filled as an output may not be necessary since it is somewhat duplicating Total Revenue. The two variables display a high degree of multicollinearity with a correlation coefficient of 0.9925.

Using two inputs and two outputs (i.e., Combination 2) in the analysis, it can be seen that Stores 1, 2 and 4 are efficient whereas Stores 3, 5 and 6 are relatively inefficient. The latter three stores fall inside the efficiency frontier formed by the former three. In order to achieve the same efficiency of the other three stores, Stores 3, 5 and 6 must either decrease their inputs or increase their outputs or achieve a combination of both.

Demand Pattern and Outbound Transport Costs
To help rationalise the retail store network, further analysis of the 2009 cost and sales data reveals the current demand pattern and service level (Table 3).

Table 3 Current demand pattern and service level

Characteristic	Observation
Highly Skewed Demand Pattern	▪ 61% of all invoices are less than $50 in amount ▪ 95% of revenue comes from one-third (33%) of customers
Very Responsive Customer Service	▪ 27% of customers are served by more than one store ▪ 96% of orders are delivered on the same day ▪ 65% of orders are delivered in the morning of the same day
High Transport Costs and Under-Utilised Vehicles	▪ On average outbound transportation cost per delivery is $10 on weekdays and $25 at weekends ▪ On average each vehicle trip makes only 4 deliveries ▪ On average 50% of vehicle trips serve only 1 to 3 customers

The analysis shows that at present the retailer is providing a very responsive customer service at relatively high transport costs with under-utilised vehicles due to lack of aggregation. This is because competition in the industry is fierce and immediate door-to-door delivery right after receipt of order has become a norm of the business. Basically orders from retail customers (individual customers with small orders) are placed through telephone calls to the stores and the products have to be delivered within a couple of hours. Otherwise customers will turn to other suppliers who are able to provide a quicker delivery service. The short lead time does not permit effective order consolidation before the delivery vehicle is dispatched. At present, the average vehicle utilisation rates of the six stores (calculated on the basis of vehicle running time and vehicle capacity utilisation) are 39%, 73%, 50%, 63%, 49%, and 50% respectively with an overall average of just above 50%. Unfortunately, as the data reveal, a large proportion of the orders are small in value. Consequently the high outbound transport costs render most of these small orders unprofitable. While it is necessary to continue to serve these minor customers for strategic reason, rationalisation of the current retail network through merging less efficient stores with efficient ones to enable better demand aggregation can help improve overall network efficiency. Also, proper customer segmentation and demarcation of service areas for individual stores can also help formulate more efficient service plans to meet the different needs of customers as well as reduce unnecessary duplication of market coverage. This, hopefully, will help increase the overall efficiency of the retail network without significantly lowering current level of customer service.

Customer Segmentation
Based on the total annual invoice amount of the orders received from the same customer, regular customers of the six stores can be divided into two main groups with high and low business value respectively. Each group can be further divided into four sub-groups based on the quantity of order (determined by the number of products ordered each time) and the regularity of order (determined by the number of orders placed in a fortnight). As a result, eight customer segments are obtained. The most important two are named Primary Core Customers and High Service Priority Customers.

Most of them are trade customers, i.e., other retailers such as supermarkets and local shops. Table 4 shows the characteristics of these two groups of customers.

Table 4 Characteristics of major customer groups

Characteristic	All Customers	Primary Core Customers	High Service Priority Customers	Total
Business Value	Mixed	High	High	
Quantity of Order	Mixed	Large	Large	
Regularity of Order	Mixed	Regular	Irregular	
Total Number of Customers	100.0%	11.4%	5.7%	17.1%
Total Products Purchased	100.0%	71.6%	14.1%	85.7%
Total Revenue	100.0%	71.9%	13.4%	85.3%

It can be seen from Table 4 that the two groups of customers, which constituted only 17.1% of the customer base, contributed to 85.3% of the total revenue. This distribution observes the Pareto rule and clearly supports the need for service plans tailor-made to cater for the needs of different customers to maximize the overall efficiency while providing the required responsiveness. Usually for trade customers, a higher level of aggregation can be achieved, as orders from these customers tend to be large in size and regular in frequency. Immediate delivery is not absolutely necessary and the longer lead time allows better planning, hence fuller utilisation of assets and resources. On the other hand, orders from retail customers are usually low in value, small in quantity, and irregular in frequency. However, immediate delivery to these customers is critical or they would turn to other suppliers. The short lead time disallows aggregation which leads to under-utilisation of assets and resources. A different service plan, such as a prizing scheme to encourage waiting, customer pickup, or bulk purchase, may help lower transport costs while still providing a relatively responsive service.

Analysis also reveals that Store 2, being the most efficient one, has the largest number of Primary Core Customers. It also has the largest total number of Primary Core and High Service Priority Customers among all stores implying that its major clients are mainly trade customers. Stores 1 and 3 have the lowest percentages of Primary Core Customers as well as the combined total implying that they have relatively more retail customers. These figures suggest that the need to cater for larger number of retail customers is probably one of the causes for their inefficiency for reason outlined in the previous paragraph. It is interesting to note that although Store 1 has the smallest number of Primary Core and High Service Priority Customers, its efficiency is not low just because its inputs in terms of equivalent number of vehicles deployed and total transport costs are relatively small. This store actually has the smallest total number of customers among the six stores but its total revenue is higher than that of Store 3 (see Table 1). However, it also has the lowest average vehicle utilisation rate (39%) suggesting that waste is present and that some form of rationalisation can be considered in the long run although currently this store is performing as efficient as Stores 2 and 4.

Market Demarcation

At present, there is a certain degree of duplication of market coverage among the six stores. For example, if a served-by-the-nearest-store principle is to be adopted, many of the current Primary Core and High Service Priority Customers of Store 2, the most efficient store in the group, should actually be served by other stores so as to save outbound transport costs. Analysis of the sales data reveals that 27% of the customers of the six stores are served by more than one store (see Table 3) suggesting a need to clearly demarcate service area for each store to avoid overlapping. When focusing only on Primary Core and High Service Priority Customers, which contributed to 85.3% of total revenue in 2009, four major service areas can be demarcated among the six stores with Stores 1 and 2 in one area and Stores 3 and 4 in another while Stores 5 and 6 each has its own area. There is little scope for rationalisation for Stores 5 and 6 as each of them serves a large neighbourhood near the city fringe and is located far from the other four stores. However, there are relatively more customers in the other two service areas served by Stores 1 and 2 and Stores 3 and 4 respectively. The higher density of customers implies a bigger scope for order consolidation to achieve higher distribution efficiency. The service area demarcation analysis suggests that Stores 1 and 2 as well as Stores 3 and 4 can be merged to consolidate demand in the long run.

Alternatively, Stores 1 and 3 can be closed if there is a change in business strategy to focus mainly on trade customers. In both cases, each service area could be served by only one store with little overlapping. This would help enhance overall network efficiency with minor impact on service level. Table 5 shows the recalculated efficiency scores of the network by combining Stores 1 and 2 and Stores 3 and 4 respectively. It can be seen that after merging, the combination of Stores 1 and 2 and that of Stores 3 and 4 become more efficient. Furthermore, the relative efficiency of the other two stores has also improved in comparison with the previous situation (see Combination 2 in Table 2), which implies a more balanced performance across the network. The calculation is based on the assumption of using the same amount of inputs and getting the same amount of outputs before and after merging. If there are ways to reduce overheads and improve vehicle utilisation rates upon the changes, the overall efficiency of the network can be further enhanced.

Table 5 Efficiency of stores upon network rationalisation

	Inputs		**Outputs**		**Efficiency**
	Vehicles	Transport Costs	Customers	Revenue	
Store					
1 & 2 Merged	36.2%	36.2%	28.6%	39.9%	1.0000
3 & 4 Merged	27.6%	27.4%	36.2%	25.7%	1.0000
5	17.9%	18.0%	18.6%	17.5%	0.9624
6	18.3%	18.3%	16.6%	18.0%	0.9014

CONCLUSIONS AND FURTHER RESEARCH

Through the analysis of transport costs and sales data of six stores of a major retailer in Australia, this study has shown that, together with techniques such as customer segmentation and spatial distribution analysis, DEA can provide a good basis for retail network rationalisation. The methodology is simpler than the full mathematical programming approach and less demanding in data requirement. The analysis is relatively easy to implement (can be done using a spreadsheet) and the outcome is straightforward to understand. Not only that DEA compares directly the efficiency of stores against that of the best performers in the group, it also shows the areas for improvement for the less efficient stores. This is ideal for managers to monitor store performance through benchmarking as well as to enforce continuous improvement. The findings in this case study clearly reveal a scope for merging stores or closing the most inefficient ones to enhance overall network efficiency. In fact, the retailer did close Store 3 in late 2010 based on the findings of this study and immediately saved more than two million Australian dollars without significantly affecting customer service.

The benefits of using DEA in network analysis are mainly its simplicity in problem formulation and flexibility in data requirement. User friendliness and easy interpretation of results are also among the advantages. As such, the methodology can be applied for continuous monitoring of store performance and identification of areas for improvement. It is very suitable for benchmarking purpose and can assist managers in setting up appropriate key performance indicators. The flexibility of the approach also permits scenario testing to help managers evaluate the effect of network rationalisation. With all these advantages, the tool can be used in conjunction with other systems to facilitate decision making in a dynamic business environment with frequent changes in demand. The findings of this study show that there is a lot of scope in applying DEA in retail network rationalisation to help improve distribution efficiency. This is particularly

important to the retail sector as expenses on distribution and replenishment usually contribute to a large percentage of the total logistics cost in the industry.
In view of the limited number of stores analysed and the relatively small set of inputs and outputs used in the analysis, this study can be regarded as a showcase to prove the feasibility and appropriateness of using DEA for retail network rationalisation. Further study in this regard can examine a bigger network of stores and consider a wider range of inputs and outputs. Instead of using a basic CCR model, other DEA models and extensions of the methodology can also be applied to encompass more subtleties in reality. This may include a staged analysis to analyse store efficiency at different stages of the operation such as from receipt of order to assortment, consolidation, and final delivery (see for example Ket & Chu, 2003; Norman & Stoker, 1991). The other direction for further research can be a disaggregate analysis of the sales output in different categories of products. This can provide a better understanding of the implications of product diversity on store performance and hence overall network efficiency (see for example Grewal et al., 1999; Vaz et al., 2010). Finally, as the selection of input and output variables is crucial in DEA, the store managers' involvement in the selection of inputs and outputs can be incorporated in the DEA analysis through the use of weight restrictions and the identification of controllable and uncontrollable factors (see for example Thomas et al., 1998; Donthu & Yoo, 1998).

ACKNOWLEDGEMENT
The authors would like to sincerely thank the retailer for providing the information used in this study.

REFERENCES

Athanassopoulos AD & Ballantine JA 1995, 'Ratio and frontier analysis for assessing corporate performance: evidence from the grocery industry in the UK', *Journal of the Operational Research Society*, vol. 46, no. 4, pp. 427-40.

Banker RD, Charnes A, & Cooper WW 1984, 'Some models for estimating technical and scale inefficiencies in data envelopment analysis', *Management Science*, vol. 30, no. 9, pp. 1078-92.

Barros CP & Alves C 2004, 'An empirical analysis of productivity growth in a Portuguese retail chain using Malmquist productivity index', *Journal of Retailing & Consumer Services*, vol. 11, no. 5, pp. 269-78.

Beasley JE 2003, 'Allocating fixed costs and resources via data envelopment analysis', *European Journal of Operational Research*, vol. 147, no. 1, pp. 198-216.

Bessent A, Bessent W, Charnes A, Cooper WW, & Thorogood N 1983, 'Evaluation of educational program proposals by means of data envelopment analysis', *Educational Administration Quarterly*, vol. 19, no. 2, pp. 82-107.

Charnes A, Cooper WW, & Rhodes E 1978, 'Measuring the efficiency of decision making units', *European Journal of Operational Research*, vol. 2, no. 6, pp. 429-44.

Charnes A, Cooper WW, Huang ZM, & Sun DB 1990, 'Polyhedral cone-ratio DEA models with an illustrative application to large commercial banks', *Journal of Econometrics*, vol. 46, no. 1/2, pp. 73-91.

Chopra S & Meindl P 2010, *Supply Chain Management: Strategy, Planning, & Operations*, Global Edition, New York: Pearson Prentice-Hall.

Deville A 2009, 'Branch banking network assessment using DEA: a benchmarking analysis – a note', *Management Accounting Research*, vol. 20, no. 4, pp. 252-61.

Donthu N & Yoo B 1998, 'Retail productivity assessment using data envelopment analysis', *Journal of Retailing*, vol. 74, no. 1, pp. 89-105.

Färe R, Grosskopf S, Lindgren B, & Ross P 1992, 'Productivity change in Swedish pharmacies 1980-1989: a non-parametric Malmquist approach', *Journal of Productivity Analysis*, vol. 3, no. 2, pp. 85-102.

Farrel MJ 1957, 'The measurement of productive efficiency', *Journal of the Royal Statistical Society*, vol. 120, no. 3, pp. 253-81.

Grewal D, Levy M, Mehrotra A, & Sharma A 1999, 'Planning merchandising decisions to account for regional assortment differences', *Journal of Retailing*, vol. 75, no. 3, pp. 405-24.

Halim RE 2010, 'Marketing productivity and profitability of Indonesian public listed manufacturing firms: an application of data envelopment analysis (DEA)', *Benchmarking: An International Journal*, vol. 17, no. 6, pp. 842-57.

Kamakura TL & Ratchford BT 1996, 'Productivity assessment of multiple retail outlets', *Journal of Retail*, vol. 72, no. 4, pp. 333-56.

Ket HT & Chu S 2003, 'Retail productivity and scale economies at the firm level: a DEA approach', *Omega*, vol. 31, no. 2, pp. 75-82.

Korhonen P & Syrjänen MJ 2004, 'Resource allocation based on efficiency analysis', *Management Science*, vol. 50, no. 8, pp. 1134-44.

Lozano S & Villa G 2004, 'Centralized resource allocation using data envelopment analysis', *Journal of Productivity Analysis*, vol. 22, no. 1/2, pp. 143-61.

Mahajan J 1991, 'A data envelopment analytic model for assessing the relative efficiency of the selling function', *European Journal of Operational Research*, vol. 53, no. 2, pp. 189-205.

Norman M & Stoker B 1991, *Data Envelopment Analysis: The Assessment of Performance*, Chichester: John Wiley and Sons.

Parsons LJ 1990, 'Assessing salesforce performance with data envelopment analysis', paper presented at TIMS Marketing Science Conference, Urbana 7, University of Illinois, Chicago, IL.

Ross A & Droge C 2002, 'An integrated benchmarking approach to distribution centre performance using DEA modeling', *Journal of Operations Management*, vol. 20, no. 1, pp. 19-32.

Talluri S, Huq F, & Pinney WE 1997, 'Application of data envelopment analysis for cell performance evaluation and process improvement in cellular manufacturing', *International Journal of Production Research*, vol. 35, no. 8, pp. 2157-70.

Thomas RR, Barr RS, Cron WL & Slocum JW 1998, 'A process for evaluating retail store efficiency: a restricted DEA approach', *International Journal of Research in Marketing*, vol. 15, no. 5, pp. 487-503.

Vaz CB, Camanho AS, & Guimarães RC 2010, 'The assessment of retailing efficiency using network data envelopment analysis', *Annals of Operations Research*, vol. 173, no. 1, pp. 5-24.

LUXURY CONSUMPTION MOVES EAST: A UK LUXURY TEXTILE MANUFACTURER PREPARES ITS SUPPLY CHAIN FOR CHINESE DEMAND

Patrick Brown, Dr. Omera Khan
Hull University Business School – Logistics Institute, UK

INTRODUCTION:

In 2009, China surpassed the United States as the second largest consumer of luxury goods, and is expected to claim the top spot from Japan by the year 2015 (China Daily, 2010). Niche luxury manufacturers in the West aiming to target the Chinese luxury market must realign their supply chain strategies to meet this geographical consumption shift, and at the same time align their service offering to the prevailing buying behaviours of the Chinese consumer (Chevalier et al, 2009). Entering the Chinese luxury market is time consuming, expensive, and fraught with risks. Only one in ten overseas consumer goods companies is profitable in china (Xiao Lu, 2008). At the same time, no luxury producer can claim to be a global luxury provider without a Chinese presence and strategy (Chadha and Husband, 2006). This paper aims to identify and explore the critical supply chain success factors a SME should consider when entering the Chinese luxury fashion marketplace. The specific focus is on luxury fashion accessories and apparel. The paper concludes with a case study that describes how a cashmere accessories producer in the UK is preparing to address these critical supply chain success factors for sales to the Chinese consumer.

LITERATURE REVIEW

The literature contains relatively little prescriptive guidance for establishing supply chain strategies in the luxury fashion marketplace (Brun, 2008). Fashion in general has received much more attention than luxury fashion in the supply chain strategy literature, but Hines and Bruce (2007) caution that fashion must not simply be equated with luxury. Non-luxury fashion brands are generally considered to have superior supply chains than luxury brands (Xiao Lu, 2008; Hexter and Woetzel, 2007), which perhaps suggests that luxury fashion supply chain strategy models remain underdeveloped. In a recent paper, Caniato et al (2009) posit that many well known, and highly cited supply chain strategy models do not necessarily apply to the luxury sector. While many of the guiding principles within these and other respected models will apply to supply chains in general regardless of sector or geography, none of the models are specific to the luxury marketplace. Therefore, Caniato el at (2009) claim, a luxury-specific set of critical success factors should be considered when designing luxury goods supply chains. Factors include: product uniqueness (including protection from counterfeits), quality, volume/variety profile to define manufacturing decisions, country of origin, and distribution.

Authors who have written on luxury brand management (Table 1) highlight many factors which must be taken into account when developing overall business strategies for the luxury market: marketing, licensing, brand creation and identity, communication, technology, retailing, amongst others. But when the lists offered by these authors are filtered for factors specific to logistics and supply chain management, common themes emerge: product design, choice of distribution strategy and product exclusivity (including intellectual property projection) are frequently mentioned. Furthermore, some authors have analysed the luxury goods sector with a specific emphasis on China, and the key critical supply chain considerations here are: Distribution methodology, country of origin, and protection from counterfeits (Table 1).

	Source/ Model	Luxury Specific	China or Asia Specific	Key Factors for Determining SC/Logistics Strategy
Sources Focused on Luxury	Nueno and Quelch (1997)	Yes	No	Product design (including the level of need for exclusivity, recognisability, uniqueness) Country of origin Distribution channel management
	Caniato et al (2009)	Yes	No	Uniqueness protection (including anti-counterfeiting) Product complexity Quality requirement Volume-variety profile Country of origin
	Okwonko (2007)	Yes	No	Method of distribution Product (quality and differentiation)
	Fionda and Moore (2009)	Yes	No	Distribution strategy (particularly customer experience at POS) Product design (specifically: product integrity, exclusivity and recognisability)
	Chevalier and Mazzalovo (2008)	Yes	No	Distribution strategy Counterfeiting Time to market Country of origin
	Brun et al (2008)	Yes	No	Quality Country of origin Product design Emotional experience/service level Brand reputation
Sources Focused on China and Luxury	Xiao Lu (2008)	Yes	Yes	Brand awareness Capital requirements Understanding of mkt Strength of local partner
	Chevalier et al (2009)	Yes	Yes	Distribution strategy to support market entry Design considerations to meet Chinese preferences Counterfeiting
	Gao et al (2009)	Yes	Yes	Design/product offerign to match variety of markets in China
	He et al (2010)	Yes	Yes	Design/product offerign to match variety of markets in China Level of counterfeit acceptance by market
	Chadha and Husband (2006)	Yes	Yes	Country of origin/sourcing Product design Counterfeits
	Hexter and Woetzel (2007)	No	Yes	Distribution IP protection Product development to compete in China Country of sourcing

Table 1: Key supply chain success factors in Chinese luxury segment

To create a frame of reference for this paper, four critical supply chain success factors in the luxury and China-specific literature will be explored: product design, country of origin, distribution strategy and counterfeiting.

Factor 1: Product Design

The literature highlights that the Chinese market is not homogonous and it is unlikely that a single design concept, marketing strategy or supply chain strategy will succeed on its own (Atsmon et al, 2009; Gao et al, 2009; Zhang, 2008). The luxury marketplace, China included, is now made up of many different price-points and categories, all of which are viable. Those companies who do not have a defined understanding of their brand, target market, and associated product design strategies to exploit these markets are at risk (Salter, 2011). Gattorna (2006) has communicated the concept of building and segmenting supply chains based on the buying behaviours of the customers, and Khan and Creazza (2009) argue that supply chain management begins with product design. With these thoughts in mind, the literature provides guidance on luxury product design by assessing what and why the Chinese consumer is purchasing.

Male/Younger Focus

While luxury fashion has tended toward the female consumer more than the male, this appears to be an inappropriate approach to product offering for the Chinese market as men account for the majority of luxury fashion expenditure (Chevalier et al, 2009). Men also engage in the common practice of exchanging expensive business gifts (Chahdha and Husband, 2006). In a recent public interview, the CEO of Burberry emphasized the men’s segment by stating that a focus of their product offering in China and elsewhere is to be more male oriented (Telegraph, 2011). Xiao Lu (2008) is but one source who stress the design and marketing focus should be geared to a much younger luxury consumer that those from the US or Europe.

Western Design
Chadha and Husband (2006) recommend that product design should not be localized to China, and that western brands should protect their international status. The Chinese consumer wants the authentic, western product unchanged from what the consumer in Paris, London or Milan can buy, as this is seen as a "link" to the western world definition of success (Willis, 2006). Furthermore, a study by Atsmon et al (2009), found that wealthy Chinese displayed a preference for foreign goods with designs identical and unmodified from those available in the western world. Some authors claim that this will change, as Chinese brands become more established and create trend setting designs (Chadha and Husband, 2006; Ghemawat, 2010), but for now the strategic recommendation would be to steer clear of any design adaptation to the Chinese market.

Factor 2: Distribution Strategy
Chevalier and Mazzalovo (2008) claim that selecting and establishing a distribution system is the most important requirement for those companies who want to expand into a worldwide luxury business. Unfortunately, they add, the luxury industry has a dismal reputation for managing logistics.

Delivering products to the Chinese consumer is a monumental challenge for a SME western luxury manufacturer. Most western SME's lack the local knowledge, relationships and capital required to do this on their own. For this reason, it is likely that the company will need to enlist the help of agents or distributors (Xaio Lu, 2008). In fact, it is expected that any new western entrant to the Chinese luxury will relinquish some level of direct customer contact. The literature specific to distribution strategy within the Chinese luxury sector identifies four main options for delivering product to the marketplace.

1. Exclusive Sales
This is one of the most likely methods for SME to enter the Chinese luxury market (Xiao Lu, 2008). In this scenario, a company sells to department stores directly or through trade fairs. The benefits of this scenario are the exposure gained by attending the trade fair and the relative ease of supplying a department store. Unfortunately, many buyers at these fairs have pre-established budgets by supplier, leaving little chance for a new player to enter. Loss of control is also a concern, as the company has less involvement in how goods are actually sold and how the customer experience is handled.

2. Subsidiaries (with potentially fully owned retail outlets)
Subsidiaries are relatively easy to set up in China (Chevalier et al, 2009), but are most appropriate for larger companies with established brand recognition and high level of market knowledge (Chevalier and Mazzalovo, 2008). Benefits include a high level of control over the marketing and customer experience. Additionally, there are no distributor margins to pay. However, experts claim that sales of at least $5M USD are required in China to make a subsidiary viable, given the marketing, sales and distribution costs that must be covered (Chevalier et al, 2009). Moore et al (2010) say that flagship retail stores are critical to the success of market entry in luxury, and should be strongly considered despite their high cost. But Chevalier and Mazzalovo (2008) argue that opening up stores in China is unwise for companies with less than 100M Euro turnover because they probably lack the brand awareness required to make stores profitable.

3. Local Distributors
A common approach to luxury goods distribution in China is to use local distributors who represent many brands and sell into large department and multi-brand stores. In this scenario, a local distributor buys imported goods, pays duties, handles physical distribution, manages advertising, and is given the right to distribute a brand within a given country or region (Chevalier and Mazzalovo, 2008; Xiao Lu, 2008). Benefits of using distributors include the leverage they have by handling multiple brands and hence significant total volume. Distributors have intimate local knowledge, allowing them to

best negotiate advertising and positioning in stores (Chevalier and Mazzalovo, 2008). Drawbacks to distributor arrangements are the loss of control in marketing, advertising, product placement in stores. Additionally, communication of the brand history and heritage will likely be weak when handled by store associates selling multiple brands in a department store setting. Indeed, Brun et al (2008) maintain that it is essential for a luxury company to have control over the customer interactions at the point of sale – this would never happen with distributors.

Hexter and Woetzel (2007) recommend that when choosing a distributor, a company must make certain that its brand represents a significant portion of the distributor's sales, and that there are not high levels of competing product in the distributor's portfolio. The literature recommends that small western companies use distributors as an entry route into China to introduce and develop their brand (Chevalier and Mazzalovo, 2008; Xiao Lu, 2008), however, companies should retain the right to buy back or share distribution rights as their brands become increasingly well known.

4. Joint Venture
A joint venture could be established with a local distributor. Such an agreement would still provide the benefits of local knowledge, but the company retains more control over the pure distributorship scenario. These are most appropriate for companies that already have a solid understanding of the local market, but do not yet want to go entirely alone.

Factor 3: Country of Origin
The literature differs on opinion about the wisdom of western firms manufacturing in luxury fashion goods in China. Some say this is not acceptable and simply will not work, other say not only is it acceptable, it may be necessary and in the producers best interest.

The Chinese luxury consumer is not yet prepared to buy a luxury fashion item with a made in China label, even if it is a famous western brand (Chadha and Husband, 2006). History, provenance, value and European style are important considerations of the luxury purchase decision, and this is often linked to country of origin (Brun et al, 2008; Gao et al, 200X; Nueno and Quelch, 1997). The Chinese, in particular, often use their luxury purchases to indicate membership to an elite western club.

On the other hand, as China emerges, homegrown competition will increase in all segments (Ghemawat, 2010). Chinese luxury brands will, and indeed already have, emerged. Similarly, western brands will gradually increase production operations in lower cost countries. Chinese manufactured luxury goods will eventually be readily accepted by the luxury consumer (Xiao Lu, 2008; Chadha and Husband, 2006). Country of origin will slowly become divorced from brand perception, as quality production and craftsmanship in various production locations becomes equal to that of the brand's home country.

Therefore, some authors caution western brands to begin planning for Chinese production, even if it is a bit too soon to put the plan into action (Ghemawat, 2010; Xiao Lu, 2008; Chadha and Husband, 2006). They claim benefits of reduced lead times to market, shorter supply chains, significantly lower labour rates, reduction in duties, and the increasing ability to tightly control licensed production make this an opportunity that cannot be ignored

Factor 4: Counterfeiting
China is the world's largest producer of counterfeit goods (Zimmerman and Chaudhry, 2009), and is the source of 80% of the world's counterfeit luxury goods (Chevalier et al, 2009). Unfortunately, the application and enforcement of anti-counterfeiting laws in

China is severely lacking (Chaudhry et al, 2009), and is not likely to improve until China's own luxury brands become victims of counterfeiting (Staake et al, 2009).

Some have proposed that counterfeiting is simply an unavoidable aspect of the luxury fashion marketplace. Staake et al (2009) report that brands may actually experience increased awareness and demand from counterfeiting, and that luxury brand customers do not perceive a reduced brand status due to wide availability of counterfeit products. However, numerous sources reflect the damaging nature of the counterfeit fashion trade, and the risks and costs of counterfeiting are significant. Lost sales, lost jobs, uncollected customs duties, brand dilution and image damage are some of the common problems arising from counterfeiting (Staake et al, 2009; Chaudhry et al, 2009; Phau and Teah, 2009).

Thus, luxury brands must be diligent in their anti-counterfeiting efforts, particularly when working within the Chinese marketplace. Gone are the days when counterfeits were purchased only by those who couldn't afford the genuine article. Certainly, cheap knockoffs are still prevalent and can be found readily, but buyers of genuine luxury goods are now true targets of counterfeit manufacturers. This is because today's counterfeiters are often capable of producing goods that are indistinguishable from the genuine product (Xiao Lu, 2008), and are even able to replicate changes in labels and swing tickets in a matter of hours (Chevalier et al, 2009). Phau and Teah (2009) describe the ability of counterfeiters to recreate a similar likeness of the genuine product as "disturbing".

The literature on counterfeiting offers relatively little guidance for practitioners to combat the phenomenon in the luxury marketplace (Staake, 2009), but a few authors have published recommended plans to actively challenge counterfeiters. There is less benefit in going after the retailers or consumers of illicit goods, and instead efforts should be focused on factories (Chadha and Husband, 2006). Chaudhry et al (2009) propose a multi-step effort to fight counterfeiting, including trademark registration, education of supply chain partners about the negative impact of counterfeit trade, monitoring procedures, and a willingness to fight criminals with evidence. Chevalier et al (2009) echo many of these recommendations, particularly with respect to registration, education and litigation. They say punishment through the legal system is the most effective counterfeit deterrent in China. Central to these recommendations is the ability to distinguish, without fail, a genuine from fake product during the process of formal investigation or prosecution.

METHODOLOGY

The research was performed using a combination of methods (Blaikie, 2000). A literature review was conducted to provide an assessment of the Chinese luxury consumer behaviour and luxury market projections, with a particular emphasis on fashion textiles. Semi-structured interviews were conducted with company production directors, sales directors, suppliers and customers to augment the literature review with recent, company-specific input. Inputs from the literature review and interviews were applied to a distribution strategy development model with an aim to identify appropriate actions that may be taken by the company to manage its supply chain as it expands into China.

CASE STUDY

The case study company is a UK-based producer of luxury cashmere and woollen accessories. The company sources raw material fibre from China, Australia and various other countries. Nearly all production takes place in the company owned and operated manufacturing sites in the UK. The company sells to large luxury brands such as Hugo Boss, Hermes and Burberry, and also markets its own branded product which is distributed through its own UK retail outlets, online and through sales agents around the globe. For the analysis the four supply chain success factors identified in the previous section (product design, country of origin, distribution strategy and counterfeits) will be the focus.

Factor 1: Product Design

The case company acknowledges a need to focus on a younger customer target for Chinese sales, but would retain the overall UK heritage and provenance of its product offering rather than try to localise it. By strongly marketing classic "heritage" type designs and patterns, the company can communicate the story of the brand and attempt to create a recognizable image, as called for by Fionda and Moore (2009). Traditional classic designs would be joined in the product offering by products developed specifically for each new season. The company would not go so far to say it would not attempt to create designs specifically targeted at the Chinese market. In fact, it does this with other countries already, and it may be considered as a new opportunity each season to attract new customers. But the core offering would remain true to the British heritage of the company.

Factor 2: Distribution Strategy/Model Application

Xaio Lu (2008) offers a model to help companies determine distribution strategies to enter the Chinese luxury market. The model is applied to the case study company in Table 2. The model considers four criteria, and recommends general distribution methodologies based on a company's relative position within each of the four criteria. The company has relatively low levels of brand recognition and market knowledge, and has relatively small amount of funding to enter into a distribution agreement. Additionally, they would want to rely heavily on the knowledge of Chinese partner in this agreement, yet still retain considerable control over distribution and sales approaches.

	Brand Recognition	Capital Availability	Market Understanding	Strength of Local Partner	
Exclusive Sales	Middle	Low	Low	High	*2nd Best Fit*
Subsidiaries	High	High	High	NA	
Local Distribution	Low	Low	Low	High	*Best Fit*
Joint Venture	High	Middle	Middle	Middle	

Table 2: Distribution strategy model for entrance into Chinese luxury Market (after Xiao Lu, 2008)

Ultimately, a combination of strategies is likely. However, creating a subsidiary or establishing into a joint venture at this early stage is not considered an appropriate entry strategy by the case company. The model points to a distributor relationship and direct sales as the two most likely strategies to enter the distribution market.

"We should focus on finding a distributor with strong coverage in the biggest markets to begin with – Shanghai and Beijing. The distributor(s) must have strong ties to luxury stores, but have little to no competing cashmere products." (Interview with Case Company Managing Director)

Company executives also spoke of holding the distributor close to retain control, making sure they have fundamental understanding of the company history and provenance, and fully cooperate with anti-counterfeiting capabilities.

Factor 3: Country of Origin:

Management acknowledge the potential benefits of a China manufacturing capacity, whether owned or licensed. Cashmere is sourced from China, imported into the UK, and finished goods are shipped to customers throughout the world. In the case of Chinese demand, the country of sourcing is also the country targeted for increased consumption.

Reduced freight costs, lead times, emissions and duties are all significant attractions to a Chinese manufacturing site. However, many countering factors were raised:

- Chinese luxury consumer demands a made in Italy or UK label for cashmere products
- Start up costs and lack of local expertise would be significant obstacles
- Corporate mission aims to provide stable employment for hundreds of UK families
- Commodity cost

"With cashmere commodity pricing at elevated heights, and the recent reports that Chinese end consumer demand for cashmere may be less than expected in the short term, it would not yet be prudent to establish production capacity in China. We should see what demand we can generate there first. It is agreed that the world's luxury consumption will be centred in this region, but our sales are not centred there yet." (Interview with Case Company Production Director)

While there is no strategic intent to produce in China immediately, the case company acknowledges the opportunity to manufacture, at least in part, within China as a future possibility. They plan to investigate how manufacturing capacity could be established, both in-house and through contract manufacturers. The investigation will include assessment of start up costs, capital investment requirements, potential partners, governmental regulations and lead times.

Factor 4: Anti-Counterfeiting Measures:
Currently, the company has little trouble with counterfeits of their own branded product. However, the goods that it manufactures for some of the world's biggest luxury brands are among the most counterfeited items in the luxury marketplace. Therefore, the company must be prepared to assist its large luxury customers with counterfeit protection, and also to pre-emptively protect its own brand.

To this end, the company is currently conducting trials with fabric DNA, a technology whereby yarn or thread used in the production of textiles can be "impregnated" with a re-sequenced DNA signature of an undisclosed plant. The DNA is virtually impossible to replicate and can be specific to a company or range of products. The technology is potentially effective as a legal tool to prove that a product is authentic or fake, and to serve notice that this particular brand has a signature built into their goods that is virtually impossible to replicate. This could serve as a deterrent to counterfeit manufacturers. DNA can also be an effective tool for the company to combat the grey or "parallel" market. The grey market is where genuine goods are obtained and sold illicitly. DNA testing could help prove that a genuine good has somehow been lifted out of its proper supply chain and introduced into an illicit one. Such deception is common among dishonest distributors or suppliers who have excess inventory of genuine goods, or the knowledge and responsibility for manufacturing genuine goods.

The literature stresses the need to partner with supply chain partners in the fight against counterfeiters (Staake et al, 2009). This perhaps applies less to the supply side of the case study company due to its vertically integrated manufacturing structure, with comparatively less risk of losing IP though its suppliers. The company believes any potential IP problems are more likely to come from illicit suppliers reverse-engineering the products, breaking them down and trying to replicate their patterns, colours and presentation. Stumpf et al (2011) conclude that a key anti-counterfeit strategy is to make the product highly distinguishable and very difficult to copy. Technology such as DNA will assist the company in proving a product is genuine.

CONCLUSION
Everyone in the luxury business needs a China strategy (Salter, 2011). Through the process of literature review, this paper has explored four supply chain factors that must be critically assessed for a SME to become successful as a new entrant to the luxury

fashion market in China. Combining literature with semi-structured interviews, the paper highlights the actions and considerations that the case study company is now undertaking with respect to product design, country of origin, Chinese distribution and counterfeiting as it prepares for increased business levels in the Chinese marketplace.

REFERENCES:

Atsmon, Y., Ding, J., Dixit, V., St. Maurice, I. and Suessmuth-Dyckerhoff, C. (2009), "The coming of age: China's new class of wealthy consumers", Insights China by McKinsey Company

Blaikie, N. (2000), *Designing social research: The logic of anticipation*, Polity Press, Cambridge

Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., Sianesi, A. and Spina, G. (2008), Logistics and supply chain management in luxury fashion retail: Empirical investigation of Italian firms, *International Journal of Production Economics*, vol. 114, no. 2, pp. 554–570.

Caniato, F., Caridi, M., Castelli, C. and Golini, R. (2009), A contingency approach for SC strategy in the Italian luxury industry: Do consolidated models fit?", *International Journal of Production Economics*, vol. 120, pp. 176-189.

Chadha, R. and Husband, P. (2006), *The cult of the luxury brand: Inside Asia's love affair with luxury*, Brealey, London

Chaudhry, P, Zimmerman, A., Peters, J., and Cordell, V. (2009), "Preserving intellectual property rights: Managerial insight into the escalating counterfeit market quandary", *Business Horizons*, Vol. 52, no. 1, pp. 57-66.

Chevalier, M. and Mazzalovo, G. (2008), *Luxury brand management: A world of privilege*, John Wiley and Sons, Singapore

Chevalier, M., Xiao Lu, P. and Toledano, S. (2009), *Luxury China: Market opportunities and potential*, John Wiley and Sons (Asia)

Chinadaily.com.cn, "China to be world's biggest luxury market in 5 yrs", 20 May 2010, Available at: http://www2.chinadaily.com.cn/bizchina/2010-05/20/content_ 9871709.htm, accessed 13 January 2011

Fionda, A. and Moore, C. (2009), "The Anatomy of the Luxury Fashion Brand", *Journal of Brand Management*, vol. 16, pp. 347–363.

Gao, L., Norton, M., Zhang, Z. and To, C. (2009), "Potential Niche Markets for Luxury Fashion Goods in China, *Journal of Fashion Marketing and Management*, vol. 13, no. 4, pp. 514-526.

Gattorna, J. (2006), *Living supply chains: How to mobilize the enterprise around delivery what your customers want*, FT Prentice Hall, London

Ghemawat, P. (2010), "Finding your strategy in the new landscape", *Harvard Business Review*, March 2010

Hexter, J. and Woetzel, J. (2007), *Operation China: From strategy to execution*, Harvard Business School Press, Boston

He, Y., Zou, D. and Jin, L. (2010), "Exploiting the goldmine: a lifestyle analysis of affluent Chinese customers", *Journal of Consumer Marketing*, vol. 27, no. 7, pp. 615-628.

Hines, T. and Bruce, M. (2007), *Fashion marketing: contemporary issues*, 2nd ed., Butterworth-Heinemann, Oxford

Khan, O. and Creazza, A. (2009), "Managing the product design-supply chain interface: Towards a roadmap to the 'design centric business'", *International Journal of Physical Distribution & Logistics Management*, vol. 39, issue 4, pp. 301.

Moore, C., Doherty, A. and Doyle, S. (2010), "Flagship stores as a market entry method: the perspective of luxury fashion retailing", *European Journal of Marketing*, vol. 44, issue 1/2, pp.139 – 161.

Nueno, J. and Quelch, J. (1998), "The Mass Marketing of Luxury", *Business Horizons*, vol. 41, no 6, pp. 61-68.

Okonkwo, U. (2007), *Luxury fashion branding: Trends, tactics and techniques,* Palgrave Macmillan, Hampshire

Phau, I. and Teah, M. (2009), "Devil wears (counterfeit) Prada: a study of antecedents and outcomes of attitudes towards counterfeits of luxury brands", *Journal of Consumer Marketing*, vol. 26, no. 1, pp. 15-27.

Salter, G. (2011), "Luxury's Coming of Age", Walpole Yearbook 2011, Published on behalf of Walpole Group by WorldWide Communications

Staake, T., Thiesse, F. and Fleisch, E. (2009), "The Emergence of Counterfeit Trade: A Literature Review", *European Journal of Marketing*, vol. 43, no. 3/4, pp. 320-349.

Stumpf, S., Chaudhry, P. and Perretta, L. (2011), "Fake: can business stanch the flow of counterfeit products?", *The Journal of Business Strategy*, vol. 32, no.2; pp. 4-12

Telegraph.co.uk, "Burberry chief Angela Ahrendts wants to 'sell the British attitude across the world'", 17 April 2011, Available at: http://www.telegraph.co.uk/finance /newsbysector/retailandconsumer/8455646, accessed 24 April 2011

Willis, M. (2006), "To Adapt or to Standardise: Testing Asian Views About Purchasing Western Luxury Products in Seven Asian Locations", *Journal of East - West Business*, vol. 12, issue 1, p. 65.

Xiao Lu, P. (2008), *Elite China: luxury consumer behavior in China,* John Wiley & Sons, Asia

Zhang, X., Grigoriou, N. and Li, L. (2008), "The myth of China as a single market", *International Journal of Market Research*, vol. 50, no. 3, pp. 377-402.

Zimmerman, A. and Chaudhry, P. (2009), "Protecting Intellectual Property Rights: The Special Case of China", *Journal of Asia - Pacific Business*, vol. 10, issue 4, p. 308.

OPERATIONAL PROCESSES AND SUPPLY CHAIN COMPETENCIES OF CHINESE LOGISTICS SERVICE PROVIDERS

Ming J Ding, Booi H Kam
RMIT University, Melbourne, Australia

Chandra S Lalwani
Business School, University of Hull, UK

INTRODUCTION

Resource Based View (RBV) has been applied extensively in supply chain studies to examine how firms utilize logistics resources to attain superior performance. Much of these studies (i.e., Cho et al. 2008; Lai et al. 2008; Shang & Marlow 2007) however, have focused on capabilities that are well-recognised supply chain imperatives, such as linkages between supply chain partners and supply chain visibilities. Relatively little attention has been directed to exploring the effects of mundane, routinized operation processes on supply chain competencies.

Logistics service providers (LSPs) routinely engage in a large array of operations. These routinized operations are socially complex, causally ambiguous, and woven into the fabrics of organizations. They are a potent source of rent-generating mechanisms, which form the backbone of flexible and agile practices vital to effective logistics and supply chain service operations. This study examines the causal linkages between routine operation processes and service competencies of Chinese LSPs.

LITERATURE REVIEW AND HYPOTHESES

Resource based View and Competency Development

RBV posits that firms have access to and control over rare, valuable, inimitable, imperfectly mobile and imperfectly substitutable resources could achieve sustainable competitive advantage (Barney 1991). These resources can be both tangible (e.g., physical assets) and intangible (e.g., product knowledge or market intelligence). RBV contends that competitive advantage could be achieved through organization and deployment of advantage-generating resources. Through repeated use and the development of firm-specific processes to exploit these resources, standard operations procedures (SOPs) emerge. Firm-specific SOPs, such as organizational processes developed to provide reliable services, create product innovations, generate operational flexibility, and respond to evolving market needs, are distinctive costly-to-imitate capabilities (Amit & Schoemaker 1993; Makadok 2001). Firms possessing bundles of advantage-generating resources and are capable of transforming them into costly-to-imitate capabilities are regarded as commanding specific competencies, which are fundamental drivers of superior performance.

Logistics and supply chain (L&SC) competencies of LSPs in China

Logistics operations in China have been described as cost-inefficient. Standing at 18.1 percent of GDP, logistics cost in China is highest among the countries in the Asia-Pacific Region and double the U.S. rate of 9.4 percent (Biederman 2010). Song and Wang (2009) attribute the high logistics costs among Chinese firms to the negligence of supply chain management concept, and lack of a systematic analysis of logistics costs.

Within the context of China's manufacturing and service industries, positioning and distribution support are two logistics and supply chain (L&SC) competencies vital to logistics services provision (Hong & Liu 2007; Wang et al. 2008). In this study, we define *positioning* as an exceptional ability to perform an extensive range of logistics and supply chain activities in innovative ways (e.g., adding sophisticated and higher value-added services to supplement logistics users' operations) dissimilar from competitors. In other words, positioning entails an ability to provide customers with high-end integrated logistics services, and a capability to deal with a wide range of logistics issues, epidemic to different parts of the supply chain, such as procurement, production, warehousing, and distribution.

We view distribution support as a firm's ability to effectively provide extensive spatial reach in freight distribution and delivery (Qureshi et al. 2008). Widespread distribution coverage has been acknowledged as a desirable feature for shippers (Cho et al. 2008) and a key aspect for competing in the Chinese market (Hong & Liu 2007; Qureshi, et al. 2008). From this perspective, positioning and distribution competencies enable LSPs to achieve service advantage and higher profits in China's highly competitive logistics service market (Wang et al. 2008).

Operations processes and L&SC competencies

This study examines the effects of three standard operation procedures (SOPs) on the above two L&SC competencies in the context of the Chinese logistics service industry. The three SOPs studied are: processes for benchmarking performance (PBP); processes for increasing responsiveness (PIR); and processes for increasing flexibility (PIF).

Benchmarking performance is a critical step in process re-engineering and is also crucial for achieving sustainable improvement in the long term (Trkman 2009). Empirical research has demonstrated that benchmarking capability is positively related to logistics competencies (Shang & Marlow 2007; Shang & Sun 2004). Firms with excellent business processes and operation procedures to measure costs and service quality can facilitate decision making process, promote coordination across different functions, and enhance logistics competencies (Shang & Marlow 2007). Effective measurement systems were found to be positively associated with performance (Stank & Lackey 1997). Thus, we posit that:

Hypothesis 1: PBP have a positive effect on (a) positioning and (b) distribution support competencies.

Responsiveness has been identified as one of the key capabilities having significant positive relationship with firm performance (Cho et al. 2008; Morash et al. 1996). Zhao, et al. (2001) contend that responsiveness is a customer-focused capability which drives firm performance. Morash et al. (1996) found that responsiveness to target market together with delivery speed, reliability, and low cost distribution are positively linked to firm performance. Therefore, LSPs with established PIR are expected to possess strong positioning and distribution support competencies, giving the following hypothesis:

Hypothesis 2: PIR have a positive effect on (a) positioning and (b) distribution support competencies.

LSPs typically regard service flexibility as an important ingredient for fostering shippers' ambitious plan of meeting customers' fast changing needs in real time. In a constantly evolving market place, LSPs with well-developed PIF would, expectedly, have a competitive edge over those less able to do so (Qureshi et al. 2008). Further, flexibility is considered a key element leading to agility in L&SC competencies (Shang & Marlow 2007; Zhao et al. 2001). High levels of operational flexibility positively impact on firms' logistics performance (Stank & Lackey 1997). In the highly regulated, yet dynamic, Chinese market, capability to develop relevant business processes to tackle barriers and challenges is expected to give LSPs an edge in service performance. Therefore,

Hypothesis 3: PIF have positive effects on (a) positioning and (b) distribution support competencies.

ICT support as a moderator

In this study, ICT support is selected as a moderator. Lai et al. (2008) suggest that ICT capability of 3PL firms is one of the most critical factors affecting the decision of a logistics user to outsource to 3PL providers. Previous studies (Cho et al. 2008; Lai et al. 2008) indicate that ICT support contributes to increasing L&SC competencies. Accordingly, the following hypotheses are proposed:

Hypothesis 4: The hypothesized positive relationships between PBP and positioning and between PBP and distribution support are stronger with the moderating effects of ICT support.

Hypothesis 5: The hypothesized positive relationships between PIR and positioning and between PIR and distribution support are stronger with the moderating effects of ICT support.

Hypothesis 6: The hypothesized positive relationships between PIF and positioning and between PIF and distribution support are stronger with the moderating effects of ICT support.

Control variables

In addition to examining the contributory effects of SOPs and the moderating effect of ICT support on L&SC competencies, we also include three control variables in our research model: warehouse and inventory management (WIM), transport and distribution network (TDN), and ICT support.

METHODOLOGY

This study is based on the responses of 76 Chinese owned logistics firms to a survey of LSPs operating in China. The survey sample was drawn from the list of logistics firms appearing in the Business Directory of Global Supply Chain Council (2009) and Business Directory of A-Z Worldwide Airfreight (2009). The two directories list a total of 1,147 logistics firms operating in China in 2009. An invitation email was sent to all the listed LSPs in July 2010, requesting them to participate in an online survey located at Zoomerange Website (www.zoomerange.com). Through undelivered emails, 311 firms were found to be no longer in existence, reducing the effective sample size to 836 firms. After two follow-up reminders, 126 completed questionnaires were received, giving an overall response rate of 15%. After data verification, nine of the partially completed questionnaires were excluded from the data file, reducing the usable sample to 117. As the focus of this study is on Chinese owned logistics firms, 41 foreign and joint venture LSPs were excluded from this analysis. Table 1 shows the sample profile of the Chinese owned LSPs used in this study.

DATA ANALYSIS

A set of items from pre-validated measurements were employed to examine L&SC competencies (dependent variables), WIM, TDN and ICT support (control variables), and PBP, PIR and PIF (independent variable), and ICT support (moderator). The measurement items for all the constructs are shown in Table 2.

Because the responses were returned in three separate waves, potential non-response bias may exist. A test of non-response bias was conducted following the recommendations of Lambert and Harrington (1990). The sample was divided into two groups: those responded after the first invitation email was issued and those responded after the follow-up email. The mean responses of the two groups to all the Likert-scale items used to form the constructs tested in this study were compared using two-sample t-tests. Results showed no significant differences (all $p > 0.05$) with respect to all Likert-scale items, suggesting that non-response bias is not a problem in this study.

Firm Characteristics	Category	Percentage (%)
Types of logistics services [a]	Freight forwarding	96.1
	Transportation	90.8
	Warehousing	84.2
	Distribution	75.0
	Inventory replenishment and control	35.5
	Logistics information systems	26.3
	Logistics system design	21.1
	Others	17.1
Ownership	State-owned	25.0
	Private	75.0
Number of full time employees	< 100	52.6
	100 – 499	36.8
	500 – 999	9.2
	> 1000	1.3
Years operated in China	0 -5	26.3
	6 – 10	34.2
	11 -15	27.6
	> 15	11.9
Annual revenue in 2008 (US$)	Less than $500K	15.8
	$500K - $ 1.0M	25.0
	$1.1M - $ 10.0M	31.6
	$10.1M - $50.0M	10.5
	> $50.0M	17.1

Note: a: Percentages in this item do not sum to 100% as multiple categories are permitted.

Table 1: Sample profile

Confirmatory factor analysis
Confirmatory factor analysis (CFA) was conducted to test the reliability, unidimensionality, convergent validity and discriminate validity of each construct following the procedure suggested by Hair et al. (2006). Five goodness of fit (GOF) indices were used: normed chi-square (χ2/df), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), normed fit index (NFI), and root mean-squared error of approximation (RMSEA). The CFA results indicate all constructs have unidimensional characteristics. All items also loaded significantly ($t > 1.96$) on their respective construct, indicating convergent validity (Anderson & Gerbing 1991). Further, the average variance extracted (AVE) for each construct is higher than 0.50, suggesting adequate convergent (Hair et al. 2006).

Discriminant validity for each construct was also established: none of the correlations between constructs was higher than the value of the square root of AVE (Fornell & Larker 1981). All Cronbach's ☐ for measurement constructs of L&SC competencies, control variables, SOPs, and ICT support are also greater than 0.728, indicating a high reliability of scales (Hair et al. 2006).

Hierarchical regression analysis
Two separate hierarchical regression analysis were undertaken to test the hypotheses using, respectively, positioning and distribution support as dependent variables. To mitigate any potential effect of multicollinearity due to the inclusion of cross-products when testing for moderation effects, all variables for the regression analysis were mean-centred (Tabachnic & Fidell 2001). Prior to carrying out the hierarchical regression

analysis, all independent variables were checked to confirm that they did not violate the assumptions of normality, multicollinearity, and homoscedasticity (Hair et al. 2006).

Variable	Item	Description	Reference
Positioning	P1	We are capable of providing innovative supply chain solutions	(Shang & Marlow 2007; Wang et al. 2008; Zhao et al. 2001)
	P2	We are capable of providing an extensive range of logistics services, including bulk-breaking, consolidation and labelling	
	P3	We are capable of accommodating unique requests by implementing pre-planned solutions	
	P4	We are capable of providing logistics expertise in a range of industries	
Distribution Support	DS1	We are capable of providing widespread or extensive distribution coverage	(Cho et al. 2008; Qureshi et al. 2008; Hong & Liu 2007)
	DS2	Our transport and distribution network has helped customers achieve cost saving	
	DS3	We are capable of providing global distribution coverage	
WIM	WIM1	Our warehousing system is capable of handling perishable goods	(Hong & Liu 2007; Wang et al. 2006;)
	WIM2	We use a variety of packing methods to minimize loss and damage of goods	
	WIM3	We have adequate warehousing facilities to support our clients' operations	
	WIM4	We often upgrade our warehouse management computer systems	
TDN	TDN1	We regularly upgrade our transport facilities	(Hong & Liu 2007; Qureshi et al. 2008)
	TDN2	We have a distribution network in the western remote areas of China	
	TDN3	We have a nation-wide distribution network to service our customers	
ICT support	ICTS1	Our information system could be readily adapted to our customers' and partners' needs	(Cho et al. 2008; Wang et al. 2008)
	ICTS2	Our information system is sufficiently secure to conduct business transactions	
	ICTS3	We are capable of integrating our operations with customers or suppliers	
PBP	PBP1	Customer service performance (e.g. order fill rate, cycle time) is regularly compared to industry standards or competitors	(Shang & Marlow 2007; Trkman 2009)
	PBP2	Operational performance (e.g. warehousing, transportation) is regularly compared to industry standards or competitors'	
	PBP3	We have in place benchmarking metrics to measure performance	
PIR	PIR1	We utilize time-based logistics solutions like continuous replenishment and Just-in-time to support customers	(Cho et al. 2008; Zhao et al. 2001)
	PIR2	We are capable of providing shorter or smaller lot size shipments	
	PIR3	We have in place operation procedures to provide door-to-door delivery services	
	PIR4	We have in place operation procedures to ensure on-time deliveries	
PIF	PIF1	Our operation schedule is triggered by customer's requirements	(Qureshi et al. 2008; Shang & Marlow 2007; Stank & Lackey; Zhao et al. 2001)
	PIF2	We have in place processes to support flexible scheduling	
	PIF3	We have in place processes to meet changing customer requirements at short notice	
	PIF4	We regularly review our service offerings in relation to customer requirements	

Note: Control variables: WIM = warehouse inventory management; TDN = transportation and distribution support; ICT support: information communication technology support; Independent variables: PBP = processes for benchmarking performance; PIR = processes for increasing responsiveness; PIF = processes for increasing flexibility; Moderator: ICT support = information communication technology support

Table 2 Variable Description

RESULTS

Table 3 shows the results of the hierarchical regression analysis. Among the three control variables, ICT support was found to have significant positive relationships with both positioning and distribution support. TDN also bears a significant positive relationship with distribution support. The effect of WIM was not significant.

For the main effects, PIR was found to uphold hypothesis H_2, bearing a statistically significant positive effect on both positioning and distribution support. PBP, however, has a significant negative effect on both positioning and distribution support, which contradicts the hypothesized relationship of H_1. PIF was found to have no significant effect on both positioning and distribution support competencies.

With respect to the moderation effect, the regression coefficients of the three interaction terms formed by the three SOP variables and ICT support were not found to be statistically significant in the positioning model. In the case of the distribution support model, the standardized coefficient of the cross-product term of ICT support and PBP was found to be positive. However, the interaction of ICT support and PIF was found to be negative, contrary to the hypothesized effect.

	Positioning			**Distribution Support**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
WIM	0.072	0.085	0.097	-0.165	-0.141	-0.037
TDN	0.041	0.091	0.089	0.156	0.202**	0.192*
ICT Support	0.800***	0.704***	0.666***	0.802***	0.758***	0.632***
PBP		-0.152**	-0.129		-0.167*	-0.086
PIR		0.159**	0.166*		0.158*	0.235**
PIF		0.119	0.090		0.025	-0.020
ICT Support x PBP			0.084			0.360**
ICT Support x PIR			0.027			0.187
ICT Support x PIF			-0.153			-0.482***
R^2	0.871	0.891	0.894	0.802	0.818	0.845
Adjusted R^2	0.749	0.777	0.772	0.628	0.640	0.675
F	75.78***	44.50***	29.26***	43.20***	23.23***	18.30***
N	76	76	76	76	76	76

Notes: 1. Control variables: WIM = warehouse inventory management; TDN = transportation and distribution support; ICT support: information communication technology support; Independent variables: PBP = processes for benchmarking performance; PIR = processes for increasing responsiveness; PIF = processes for increasing flexibility; Moderator: ICT support = information communication technology support
2. Figures shown are standardized coefficients (i.e., beta values)
3. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$

Table 3 Result of Hierarchical Multiple Regression Analysis

DISCUSSION

The results suggest that ICT support is a key asset in logistics and supply chain operations in China. Chinese LSPs with strong ICT support are better able to provide an extensive range of high-end integrated logistics services as well as excelling in freight distribution and delivery services. This finding is consistent with those of Lai et al. (2008) and Wang et al. (2008), who found that ICT support is positively associated with LSP' performance. TDN, widespread distribution coverage, is also an important physical resource in supporting freight distribution and delivery, confirming the research of Hong et al. (2007), Qureshi et al. (2008), and Cho et al. (2008).

The significant positive effects that PIR has on both positioning and distribution support reaffirm the conventional wisdom that responsiveness to market and customer needs is one of the main factors contributing to L&SC competencies, empirically validating the findings of several previous studies (Zhao et al. 2001, Shang and Marlow 2007; Cho et al. 2008). Features such as delivery speed and reliability, and responsiveness to target market are essential capabilities for competing in the Chinese market. Having relevant business processes to achieve delivery speed and ensure reliability and responsiveness are critical ingredients for Chinese LSPs to develop their positioning and distribution support competencies.

While the finding on the effect of PIR confirms those of earlier studies, the significant negative effect that PBP has on both positioning and distribution support competencies contradict those of Shang and Sun (2004), and Shang and Marlow (2007). The unexpected inverse relationship implies that processes for benchmarking performance have counterproductive consequences in the case of Chinese LSPs, the majority of which have no such formalized SOPs. Given that the Chinese logistics market has been described as structurally fragmented (Hu et al. 2008), we interpret that benchmarking is not a straight forward notion as in the case of a mature market where performance is judged by a well-acknowledged set of subscribed indicators. With different groups of LSPs competing in dissimilar ways, benchmarking is a complex issue. Attempts to develop processes for benchmarking not only appear to be ineffective but counterproductive.

On the moderating effects that ICT support has on the relationships between the three SOP variables and the two L&SC competencies, the results reveal that ICT support has dissimilar effect on different SOPs. ICT support does not moderate the relationship between the three SOPs and positioning competency. In the case of distribution support, ICT support enhances the effect of PBP but dampens that of PIF. Because PBP, or processes for benchmarking, require data support, data integration and market intelligence, ICT support would be of help in strengthening the effect this SOP has on distribution support. By contrast, PIF is an activity-driven, complex and sophisticated process. It does not follow a single standardized process typically. PIF, as a logistics capability, is an ac-hoc activity accomplished by combining different business processes innovatively according to the exigencies of the situation. This is expected in a highly dynamic market Like China. In order to adaptively respond to unpredictable environmental changes, processes established for achieving flexibility necessarily involve a high degree of variation, which calls for very high powered ICT skills and capabilities. This argument is supported by Langley (2007), who found that ICT support was least important in emerging markets, like China, where majority of logistics users are dissatisfied with the ICT capabilities of LSPs. This explains the counter-productive effect that ICT support had on the relationship between PIF and distribution support.

CONCLUSION

Set against the backdrop of the structurally fragmented Chinese logistics industry (Hu et al. 2008), this research unveils some of the less well understood relationships between SOPs and L&SC competencies. While some of the hypothesized relationships were confirmed, the unexpected inverse relationships found between PBP (processes for performance benchmarking) and the two L&SC competencies cast new light on the counterproductive consequences of performance benchmarking in the Chinese logistics market, opening fruitful avenues for further research. Insights into the effectiveness of different SOPs on positioning and distribution support and the role of ICT in moderating the strength of these relationships provide useful commercial information for firms that yearn to succeed in the lucrative but underdeveloped Chinese logistics market.

REFERENCES

Amit, R & Schoemaker, P 1993, 'Strategic assets and organizational rent', *Strategic Management Journal*, vol. 14, no. 1, pp. 33-46.

Anderson, J & Gerbing, D 1991, 'Predicting the performance of measures in a confirmtory factor analysis with a pretest assessment of the substantive validities', *Journal of Applied Psychology*, vol. 76, no. 5, pp. 732-40.
Barney, J 1991, 'Firm resources and sustained competitive advantage', *Journal of Management*, vol. 17, no. 1, pp. 99-120.
Biederman, D 2010, 'Asias logistics tigers', *Journal of Commerce*, vol. 7, no. 3, pp. 5-7.
Business Directory of A-Z Worldwide Airfreight 2009, 01 July 2009, <http://www.azfreight.com/azworld/aw13605.cfm>.
Business Directory of Global Supply Chain Council 2009, 20 July 2009, <http://www.supplychain.cn/en/directories/>.
Cho, J, Ozment, J & Sink, H 2008, 'Logistics capability logistics outsourcing and firm performance in an e-commerce market', *International Journal of Physical Distribution & Logistics Management*, vol. 38, no. 5, pp. 336-59.
Fornell, C & Larker, D 1981, 'Evaluating structural equation models with unobservable variables and measurement error', *Journal of Marketing Research*, vol. 18, pp. 39-50.
Hair, J, Blac, W, Babin, B, Anderson, R & Tatham, R 2006, *Multivariate Data Analysis*, Pearson Prentice Hall, Upper Saddle River, New Jersey 07458.
Hong, J & Liu, B 2007, 'Logistics development in China: a provider perspective', *Transportation Journal*, vol. 46, no. 2, pp. 55-65.
Hu, DQ, Wang, SL & liu, N 2008, 'Current status and development of China logistics firms', *China Logistics and Purchasing (Chinese)*, vol. 280, no. 3, pp. 62-3.
Lai, F, Li, D, Wang, Q & Zhao, X 2008, 'The information technology capability of third party logistics providers: a resource-based view and empirical evidence from China', *Journal of Supply Chain Management*, vol. 44, no. 3, pp. 22-38.
Lambert, D & TC., H 1990, 'Measuring nonresponse bias in customer service mail surveys', *Jounal of Business Logistics*, vol. 11, no. 2, pp. 5-25.
Langley, J 2007, 'The state of logistics outsourcing: 2007 Third-party logistics', *Georgia Institute of Technology*, viewed 10 July 2010, <http://3plstudy.com/p=2007-3pl-study>.
Makadok, R 2001, 'Toward a synthesis of the resource-based and dynamic-capability views of rent creation', *Strategic Management Journal*, vol. 22, no. 5, pp. 387-402.
Morash, EA, Droge, CLM & Vickery, SK 1996, 'Strategic logistics capabilities for competitive advantage and firm success', *Journal of Business Logistics*, vol. 17, no. 1, pp. 1-22.
Qureshi, MN, Dinesh, K & Pradeep, K 2008, 'An integrated model to identify and classify the key criteria and their role in the assessment of 3PL services providers', *Asia Pacific Journal of Marketing and Logistics*, vol. 20, no. 2, pp. 227-49.
Shang, K-C & Marlow, PB 2007, 'The effects of logistics competency on performance', *Journal of International Logistics and Trade*, vol. 5, no. 2, pp. 45-66.
Shang, K-C & Sun, L-F 2004, 'Taxonomy in logistics management: A resource-based perspective', *International Journal of Management*, vol. 21, no. 2, pp. 149-65.
Song, H & Wang, L 2009, 'The status and development of logistics cost management: evidence from Mainland China', *Benchmarking*, vol. 16, no. 5, p. 657.
Stank, TP & Lackey, J 1997, 'Enhancing performance through logistical capabilities in Mexican maquiladora firms', *Journal of Business Logistics*, vol. 18, no. 1, pp. 91-123.
Tabachnic, BG & Fidell, LS 2001, *Using Multivariate Statistics*, 3rd edn, Harper Collins, New York.
Trkman, P 2009, 'The critical success factors of business process management', *International Journal of Information Management*, vol. 30, no. 2, pp. 125-34.
Wang, Q, Chu, Z, Zhou, Q & Lai, F 2008, 'A comparative study of third-party logistics in Mainland China and Hong Kong', *Transporation Journal*, vol. 47, no. 3, pp. 48-58.
Zhao, M, Droge, C & Stank, TP 2001, 'The effects of logistics capabilities on firm performance: Customer-focused versus information-focused capabilities', *Journal of Business Logistics*, vol. 22, no. 2, pp. 91-107.

LEVERAGE EFFECT OF SUPPLIER MANAGEMENT ON SUSTAINABLE PROCUREMENT IN EMERGING MARKETS

Straube, F., Özgen, A., Ouyeder, O.

Prof. Dr.-Ing. Frank Straube, Head of Logistics Department, Assistant Prof. Dr.-Ing. Arzum Özgen, Post Doctoral Fellow and Research Associate, Dipl.-Ing. Ouelid Ouyeder, Research Associate, Logistics Department, Berlin University of Technology

ABSTRACT
Purpose:
Industrial companies that are sourcing in emerging markets realize great opportunities and competitive advantages and benefit from the specific competencies of local firms for their procurement activities. However, procurement companies face challenges and risks in emerging markets. This research paper analyses how Top Performer companies achieve success in their target emerging markets and accomplish an excellent performance through strategic decisions and measures related to innovative supplier management, successful sourcing as well as the implementation of sustainable procurement.

1. Introduction

Since several decades, emerging markets increase their importance regarding the procurement and supply of more complicated products as well as simpler parts and components. This has necessitated a much more developed and extended supply chain network to fulfill the production and manufacturing needs of developed countries. International procurement companies should improve and integrate their supplier management processes in emerging markets with their entire production and supply structures in order to protect their global competencies. Enormous push from global markets enforces procurement companies to set up and develop long term relations with their suppliers in emerging markets. Supplier selection as the first step has a long lasting effect on supplier management performance in emerging markets. In second stage procurement companies should integrate their suppliers with their global supply chains by focusing on supplier management and development activities.

Sustainable procurement as a new topic encompassing economic, environmental and social aspects is increasing in importance due to its impact on successful emerging markets sourcing. Procurement managers are developing sustainability in their procurement processes because of the growing importance of climate change and limited resources as well as the potential of cost advantages. Procurement companies as well take bidirectional positive effect of sustainable procurement and supplier management.

2. Literature review

International procurement has been studied extensively in literature by researchers (such as Spekman et al., 1991; Birou and Fawcett, 1993; Herbig and O'Hara, 1996; Nellore et al., 2001; Nassimbeni and Sartor, 2007, Javalgi et al. 2009, Maltz et al. 2011) to determine the main motives and challenges regarding developing a procurement and sourcing base in international environments and emerging markets.

Logistics and the supply chain management (SCM) are emerging as the critical success factors for companies operating in the international arena, as increasing complexity arises from a wider range of products, technological development, market growth and the number of supply chain actors (Braithwaite and Christopher, 1991). At this point performance evaluation of suppliers in selection and development phase will help procurement companies to adjust objectives and success factors of the company with suppliers (Chang, 2005). Krause and Ellram (1997) state that trust and reliance of procurement companies on their suppliers to deliver technologically advanced, defect-free products, in a timely, cost-effective manner necessitates supplier development activities which is defined as; any effort of a buying firm with its supplier(s) to increase the performance and/or capabilities of the supplier and meet the buying firm's short- and/or long-term supply needs.

Sustainable development is mentioned in the Brundtland Report as: ''Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'' (WCDE, 1987). A study conducted by Harwood and Humby (2008), presents that 20% of the firms viewed sustainability issues as their largest supply chain risk and 25% of the firms required suppliers to adhere to social and ecological standards in order to mitigate supply chain risks (Foerstl et al. 2010). This risk mainly could be explained by procurement companies' public reputation and its market share by taking the responsibility of their suppliers in front of the public opinion. Therefore integrating sustainability aspects (e.g. environmental and social aspects) in supply process will help in determining new supplier selection and evaluation criteria (Koplin et al. 2007). Koplin et al. explained the main trends affecting the relationship between sustainability and supply management as the increasing strategic importance of supply management and the awareness of the connection between supply decisions and a firm's environmental and social or sustainable performance. As a result, including sustainability in procurement and supply management processes of the international procurement company will help to reduce the environmental harms and social problems which as well leverage the economic aspects of the company along the entire supply chain.

3. Methodology

This survey has been conducted based on a questionnaire in three different languages: English, Chinese and Turkish. This flexibility facilitated the companies' participation and enabled the project team to achieve a high response rate of 332 participants. Participants of the survey consist of multinational companies from small and medium-sized enterprises to global players. Buying companies are located in Germany, the USA, Brazil, Turkey, Russia and China. German companies' procurement headquarters have been reached through the databases of the BVL and the TU Berlin. Non-European companies' procurement headquarters and local procurement offices were reached via cooperating partners' contacts.

This study has different areas of key findings: The evaluation is carried out for three main topics: trends and strategies in emerging markets, supplier management and sustainable procurement. Results about successful concepts and strategies have been classified into two different groups of respondents: overall companies which represent total responses and Top Performer companies. The evaluation method is based on three different approaches: 1) Responses that are based on five intervals Likert scale are evaluated and measured for fourth and fifth interval representing important and very important for a specific item. 2) Other questions are evaluated by the statistical mean based on specifications in blank response fields. 3) Open questions enabled the project team to collect additional information.

Definition of the "Top Performer" companies

In order to determine Top Performer companies, a set of criteria related to Top Performance has been developed. In this study, Top Performer companies are defined based on the one hand on their excellent performance in achieving best cost savings potentials in their sourcing in emerging markets.

A successful supplier management is verified through several critical selection criteria. For example, the willingness of suppliers to cooperate with the procurement company is considered a success factor. Development and collaboration capabilities such as know-how transfer and information exchange of planning data between Top Performer companies and suppliers are relevant, and are therefore selected as additional criteria.

The implementation level of sustainable procurement is chosen as an additional success criterion for Top Performers due to its positive effects on a successful business. Implementing sustainable procurement has been actively pursued by Top Performer companies. This is due to the potential cost benefits and the contribution of sustainable procurement to enable close and successful cooperation with suppliers in order to achieve better performance in emerging markets. All of identified Top Performer companies in this study are pursuing sustainable procurement objectives.

As a result, 12% of participating companies are identified as Top Performers. The group of Top Performers is located in worldwide regions and includes companies of different sectors, mostly operating in the electronics sector (24%), followed by machines and plant (18%) and the automotive sector (9%). They are SME, large companies and belonging as well to global players. Top Performer companies are realizing different annual turnovers (42% with an annual turnover of more than 500 million euros, 33% with an annual turnover between 50 - 500 million euros, 25% with less than 50 million euros). The results show that Top Performer companies' profile is diversified and can be found in different regions, sectors and company sizes.

4. RESULTS

This section provides the key findings of the study in the field of objectives and challenges, supplier management and sustainable procurement in emerging markets. Based on the responses of participating companies the following aspects are discussed:

- challenges and opportunities of procurement companies in emerging markets
- the extent of supplier management concepts implemented by procurement companies in their Emerging Markets activities
- identified supplier development strategies used by procurement companies
- the current status and importance of sustainable procurement methods

Objectives and Challenges

Procurement companies' essential objective – cost savings- are not alone a sufficient success factor in emerging markets sourcing. Operating in emerging markets requires further high priority objectives. 75% of procurement companies are pursuing cost savings as their most important objective in sourcing from emerging markets. The share of material costs affect the total procurement costs, and at the same time reductions in price and costs have a direct influence on the operating profit. 57% of procurement companies determined the establishment of a local supply chain as the second main objective for presence on-site. This is an important goal: on the one hand, in order to benefit from future market growth in emerging markets, and on the other hand, in order to reduce efforts with local-content regulations. 49% of the participants are pursuing the implementation of a sustainable procurement, since its relevance in business operations is increasing.

Cost savings is indicated by 83% of Top Performers as being the most important objective, but this is not the only reason why they are sourcing from emerging markets. Based on their supplier management efforts, Top Performers set additional objectives which are related to product development cooperation (62%), sustainable procurement (59%) and technical know-how (49%) in order to achieve strong supplier partnership. Top Performer companies are in a position to pursue their set of objectives simultaneously because they provide sufficient resources and focus on long-term planning.

The main challenges are identified in the areas of product quality (77%), logistics infrastructure (74%) and communication (69%), as well as lack of supplier qualification (68%). Procurement companies often rate the challenges in their emerging markets operations, as being easy to solve, but study findings show that, compared to Top Performer companies, they underestimate these challenges. The comparison of challenges in the procurement process in emerging markets highlights the finding of suitable suppliers as the key criterion for successful procurement. Finding suitable suppliers is a difficult process due to the lack of those with sufficient qualifications as well as to deficits in production facilities in emerging markets. The second main challenge is the logistics infrastructure and processes in emerging markets which have a great influence on the logistics performance. The cultural factors and the negotiation mindset in particular complicate a smooth collaboration in emerging markets. For this reason, Top Performers seek to improve and expand the capabilities of their suppliers through collaboration.

Product quality challenges are still among the greatest important challenges in emerging markets as stated by 58% of the Top Performers, but their efforts in supplier management, in particular supplier development, have a positive effect on increasing the product quality delivered by suppliers. These efforts include supporting the suppliers with training and knowledge transfer.

Supplier selection and development
This study has identified different approaches in supplier selection process, since it becomes increasingly important as a factor in supplier management: traditional selection criteria such as price and quality are used by overall participants, whereas the identified Top Performer companies differ by applying a strategic focus, with a view to establishing long-term supplier relationships. Procurement companies are using product quality (92%), price (90%) as well as suppliers' service level (80%) as their main supplier selection criteria. Service level incorporates short lead time delivery and the suppliers' flexibility. Companies in the category of overall respondents do not emphasize as much as Top Performer companies the importance of benefits from the supplier development potentials (60%) as a selection criterion.

Top Performer companies consider appropriate selection criteria, in addition to price and quality. In order to achieve a higher supplier performance, Top Performer companies are involving strategic selection criteria such as willingness to collaborate (95%) and product development capabilities (84%). The environmental and social responsibility of a supplier is also required by the majority of the Top Performer companies. Furthermore, 70% of the Top Performer companies emphasize the relevance of the suppliers' development potential. This strategic approach ensures Top Performer companies the successful, long-term cooperation of highly qualified suppliers. This decision is crucial for the next step, supplier development.

Supplier capabilities in terms of technical aspects, quality, costs and reliable delivery has a significant effect on procurement companies' performance in fulfilling their customers' requirements. Likewise supplier development efforts will assure them long-term competitiveness in their sourcing activities and minimize supply risks. In this study, the supplier development strategies that procurement companies are applying are classified in three categories, determined as follows: basic, arm's-length and active-enabling strategy (refer to figure 1). A common development strategy (arm's-length) is to push the suppliers to improve their capabilities (52%) in areas like product quality, delivery capabilities, costs or even technical issues related to product specifications. Penalties (52%) are applied if the supplier cannot fulfill his obligations in terms of service and product quality. Top Performer companies additionally pursue an active-enabling supplier development process by providing material and personnel resources as well as technical know-how. Providing training (61%) and technology (know-how) transfer (62%) are important elements of an active-enabling strategy. Based on these activities, an average

61% of the Top Performer companies enable their suppliers to develop themselves according to the company‘s own requirements and expectations. These development efforts support the competitiveness of buying companies by achieving cost reduction, increased product quality and improved service levels in the long-term. This shows that Top Performer companies have recognized the importance of supplier management for successful procurement in emerging markets. They select their suppliers based on strategic criteria, they develop them by providing resources and they seek to integrate them in their organization in order to benefit from a higher service level in a long-term partnership.

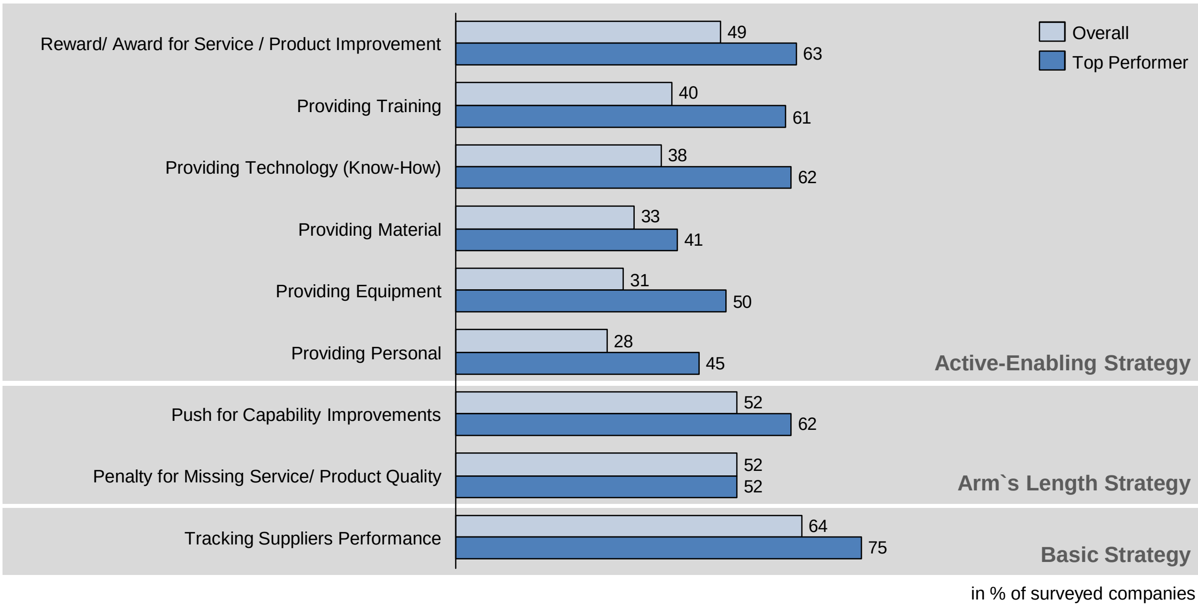


Figure 1: supplier development in emerging markets

Motivation for and challenges of implementing sustainable procurement

49 % of the surveyed companies identified sustainability as an objective to pursue in emerging markets. They found sustainability to be an instrument for developing procurement strategies in order to make more efficient use of resources, e.g. energy and materials. From the Top Performers’ perspective, the main motivation for sustainable procurement is cost reduction (85%) in order to achieve an efficient resource management. Minimizing risks related to defensive sustainability strategy (77%) is another important motivation in order to avoid loss of reputation and competitiveness, and to improve the brand/image (67%). The top 3 sustainable procurement motivations; cost reduction, risk minimization and compliance are basically related to the traditional objectives of business economics. These objectives have been started to be integrated into operations by Top Performer companies in their business processes. In conclusion, sustainable procurement does not only help them to achieve improved cost and performance in their activities, it supports them in their relationships and cooperation with their suppliers in the long-term period.

Study findings show that the challenges facing in the implementation of sustainable procurement fall into two categories: know-how-related and resource-related challenges. The former refers to the group of overall participants, while the latter applies to Top Performer companies. Overall participants mention lack of experience in sustainable procurement (42%), lack of metrics (37%) or contradictory objectives (36%) as challenges, and stress the need for clarification and knowledge in these areas. The implementation of sustainable procurement seems to be non-transparent and complex for overall respondents. This result shows that research institutions need to continue researching sustainability in order to provide parties with applied and standardized practical solutions.

Most of the Top Performers overcome know-how related challenges, such as lack of experience, and are currently facing resource related challenges, e.g. resistance from suppliers (41%) and, lack of Top-Management Support (36%). Suppliers' resistance to implement sustainable procurement is one of the challenges related to a company's external environment. The lack of personnel and financial support from top management must be overcome in order to achieve an effective implementation of sustainable procurement methods within the company. Consequently, the readiness for sustainability seems to remain low, making it difficult to implement sustainable procurement methods in practice.

Importance and implementation level of sustainable procurement

In this study, respondents indicated the importance of sustainable procurement and the actual level of implementation. Procurement companies prioritize specific topics for the different aspects of sustainable procurement. For instance, transport efficiency as an economic aspect, avoiding environmental pollution and the abandonment of child labor usage are the most relevant aspects. These measures are usually widespread in their application. This means that, when it comes to sustainable procurement, methods and measures seems to have higher relevance if the procurement companies have experience and if measures are already in use.

Social aspects have been playing a decisive role in minimizing risks to companies' reputation. 49% of the surveyed companies indicated that they first and foremost consider the importance of social aspects. They are aware of the important role of human resources in their procurement activities, and concern themselves with labor conditions and child labor issues. In this study, the importance of efforts against child labor is remarkable, since only 76% of the participants of the group of 49% see this objective as being very important.

Top Performer companies have a higher perception of both importance and implementation compare to the group of 49% overall. Social aspects (average 77%) are prioritized in sustainable procurement, followed by economic aspects (64%) due to cost reduction potentials. An average 53% of Top Performer companies emphasize the importance of environmental aspects compared to average 40% of overall respondents. "Implementation level" of sustainable procurement aspects follows the same order as the "importance level" that companies

indicated before. Implementation level (average 47%) falls behind defined importance level (average 65%) due to resource-related challenges. The differences between the importance and implementation of sustainable procurement are significant, but Top Performer companies pursue all three dimension of sustainable procurement (refer to figure 2). For instance, in the field of economic aspects, transport efficiency has been implemented by 54% of the Top Performer companies. However, minimizing costs is ostensibly the reason for this sustainability approach. Furthermore, 42% of the group of Top Performer companies focuses mainly on activities like the prevention of environmental pollution. This high implementation level can be attributed to both environmental regulations and existing suppliers' certifications. In contrast, for example, the "carbon foot print check"- a method for measuring and reporting greenhouse gases- must be specifically mentioned in the presentation of results. While 40% of the Top Performer companies indicate that the carbon foot print check is particularly important, just 16% of these respondents have implemented this goal. One reason for this discrepancy is the lack of internationally accepted standards for measuring greenhouse gases and emissions along the supply chain.

The fulfillment of environmental and social objectives reduces the risk of negative perception of the companies' reputations in society, thereby losing a competitive edge.

Nowadays, stakeholders such as customers or non-governmental organizations (NGOs) closely follow the activities of multinational companies. The implementation of environmental methods as a part of sustainable procurement is in an early stage, and this step is primarily taken by Top Performer companies. Pursuing sustainable procurement does not only help them to achieve better cost and performance levels in their activities, it also aids them in their relationships and cooperation with their suppliers.

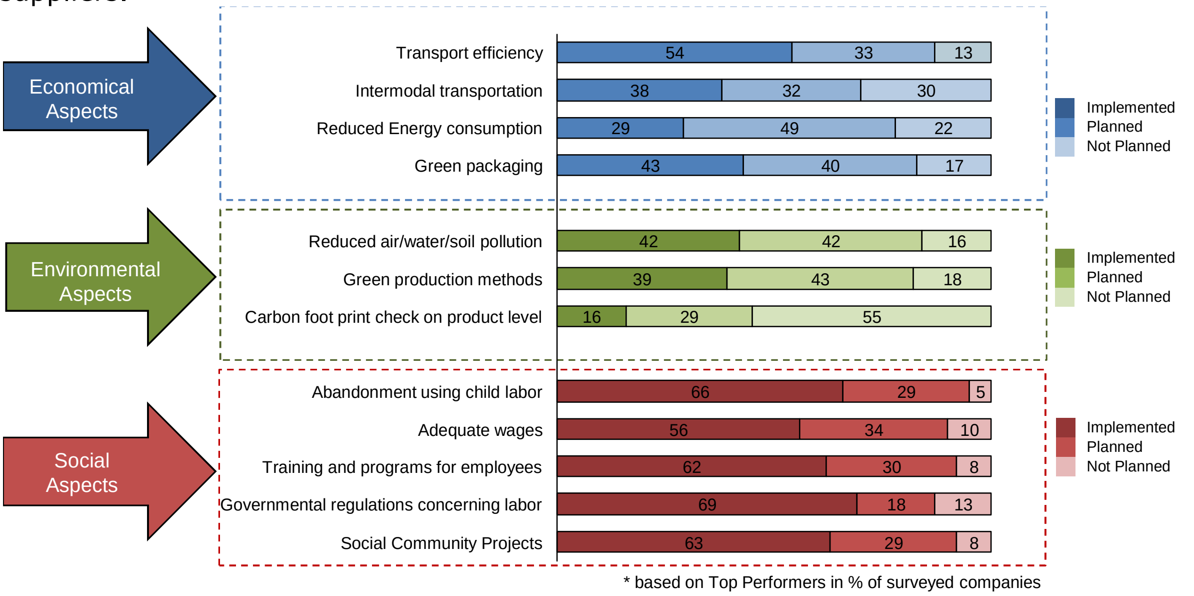


Figure 2: top performer companies' implementation level of sustainable procurement

CONCLUSION

Procurement companies, especially Top Performer companies, have adopted new motivations in order to benefit more from the inherent advantages of emerging markets such as low product/service costs and labor wages. They are setting objectives and establishing product development partnerships, which leads to increase in their supplier development and collaboration activities. Therefore partnerships are only able to be established with suitably skilled suppliers and it requires a differentiated approach. Before procurement companies start developing their partnership, they should evaluate the development potential of supplier in the selection as well. Supplier development strategies of claiming and fostering might be pursued as follows: procurement companies should push for improvements, check the progress and support the development of the supplier with know-how, technical and personnel resources.

Procurement companies are facing two stages of challenges in sustainable procurement implementation in emerging markets. Firstly, they have to take steps to overcome know-how-related challenges such as lack of experience. But as soon they have overcome the know-how-related challenges, they need to be aware of resource-related challenges such as lack of budget. But as a key to success in the implementation of sustainable procurement, companies need to convince their suppliers to comply with companies' sustainable procurement requirements. Efforts in supplier development and partnerships might have a positive effect on the implementation level of a sustainable procurement. Top Performers are aware of a better cost performance in the long-term perspective. This would provide a win-win situation for both parties.

Procurement companies should prioritize specific topics in each dimension (economical, environmental and social) of sustainable procurement. It might be easier to start with the most relevant common measures, such as transport efficiency as an economical aspect, and the avoidance of environmental pollution and abandonment of child usage.

An increasing implementation level could be achieved in the future by following a holistic and top-down approach as part of corporate strategy within the procurement company and with the suppliers. Sustainable procurement is a recipe for a successful sourcing as indicated by Top Performer companies, even in emerging markets.

REFERENCES

Birou L. and Fawcett S. (1993), "International purchasing: benefits, requirements and challenges", International Journal of Purchasing and Materials Management 29 (2), 28–37.

Braithwaite A. and Christopher M. (1991) "Managing the global pipeline", in International Journal of Logistics Management, 2 (2), 55-62.
Handfield R. (1994) "US global sourcing: patterns of development", International Journal of Operations and Production Management, 14 (6), 40–51.

Chang, H.H. (2005) "The influence of continuous improvement and performance factors in total quality organizations", Total Quality Management and Business Excellence, 16 (3), 415–439.

Foerstl K., Reuter C., Hartmann E. and Blome C. (2010) "Managing supplier sustainability risks in a dynamically changing environment-Sustainable supplier management in the chemical industry", Journal of Purchasing and Supply Management, 16 (2), 118-130.

Harwood I. and Humby S. (2008)"Embedding corporate responsibility into supply: a snapshot of progress", European Management Journal, 3 (26), 166-174.

Herbig, P. and O'Hara, B. (1996) "International procurement practices: a matter of relationships", Management Decision, 34 (4), 41–45.

Javalgi R.-G., Dixit A. and Scherer R.-F. (2009) "Outsourcing to emerging markets: Theoretical perspectives and policy implications", Journal of International Management 15, 156–168.

Koplin J., Seuring S. and Mesterharm M. (2007) "Incorporating sustainability into supply management in the automotive industry – the case of the Volkswagen AG", Journal of Cleaner Production, 15 (11-12), 1053-1062.

Krause D. R. and Ellram L. M. (1997) "Critical elements of supplier development", European Journal of Purchasing and Supply Management, 3, 21-31.

Maltz A., Carter J. R. and Maltz E. (2011) "How managers make sourcing decisions about low cost regions: Insights from perceptual mapping", Industrial Marketing Management, doi:10.1016/j.indmarman.2011.01.003.

Nassimbeni G. and Sartor M. (2007) "Sourcing in China: a typology", Internatinoal Journal of Production Economics, 107, 333-349.

Nellore R., Chanaron J.-J. and Soderquist K. E. (2001) "Lean supply and price-based global sourcing-the interconnection", European Journal of Purchasing and Supply Management 7, 101–110.

Spekman J., Spear J. and Kamuff J. (1991) "Towards more effective sourcing and supplier management", European Journal of Purchasing and Supply Management 5, 103–116.

WCDE (World Commission on Environment and Development) (1987) "Our Common Future", Oxford University Press, Oxford, p. 400.

PRODUCT RETURNS MANAGEMENT: A VALUE CREATION FRAMEWORK

G Peter Dapiran and Booi Kam
School of Business Information Technology & Logistics
RMIT University, Australia

INTRODUCTION

Managing the return of products from their retailer customers poses a challenge to many suppliers. In the consumer electronics sector, retailers return products to their suppliers for a number of reasons (Lee & Lund, 2003; Mollenkopf & Dapiran, 2007; Pollock, 2010; WERC, 2007):

- Genuinely faulty products. These are obviously non-working or damaged products.
- Claimed faulty products. These are products that have been returned to the retail store by consumers claiming the products to be faulty. The consumer has been given a credit or replacement product consistent with the retailer's customer service policy. Sometimes these goods are found *not* be faulty when eventually tested by the supplier. These products, commonly known in the industry as No Fault Found (NFF) products, give rise to disputes between the supplier and retailer as to whom should bear the costs for these returns.
- Excess stock. Returns to the supplier of these products are negotiated between retailer and supplier.

Managing product returns is an extremely costly exercise for both the supplier and the retailer. In the USA the cost to the industry of "assessing, repairing, reboxing, restocking and reselling returned merchandise" is estimated to be US$13.8 billion a year in a market valued at US$160 billion wholesale (Accenture, 2007). In the UK, returns comprise between 4% and 30% of sales value (Bernon & Cullen, 2007). While costs are incurred by both retailer and supplier, the question of which party should carry the cost burden is often disputed.

Problems arise because of the different perspectives of supplier and retailer. Retailers accept returns from their customers to maintain a service policy and are not that focused, in the retail store environment, in confirming the accuracy of the customer's claims regarding product defects or malfunction. There is a significant gap between customer reasons for product returns and those of the trader as Table 1 indicates (Accenture, 2007).

Return Reasons	***Customer Perspective***	***Supplier / Retailer Perspective***
Buyer remorse	26%	27%
Defective product	25%	5%
Product not working as expected	49%	-
No fault found (NFF)	-	68%

Table 1: Reasons for product returns (Accenture, 2007)
(Compiled by Accenture from their own data and other various studies)

With such a high proportion of returned products being categorised as NFF, suppliers perceive that they are bearing an unnecessary cost. The retailer, potentially burdened with the cost of carrying inventory of product returned by customers, takes the expedient approach of returning the product to the supplier. The focus of both parties fixes on minimising their own costs with little effort dedicated to exploring the value potential of the product returns process (Mollenkopf & Dapiran, 2007).

Value creation has long been recognised as an important innovative supply chain initiative that gives chain members competitive advantage (see for example Dietl, Royer, & Stratmann (2009). While there is no shortage of literature on value creation through supply chain collaboration (Horvath, 2001) and supply chain integration (Tuominen, 2004), the bulk of these studies has been conducted in the context of the forward product chain. Comparable discussions in reverse logistics are few and far between, let alone in the management of product returns (Mollenkopf, Frankel, & Russo, 2011).

The lack of predictability, low volume (compared to the forward chain), and high variety involved in the flow of return products have been some of the underlying causes that product returns is generally under-researched with few studies perceiving product returns has a link to value (Mollenkopf, et al., 2011).

Several research questions arise in this context:

- What constitutes value in the product returns process?
- How can suppliers extract value from a product returns process?

Viewing product returns from the value perspective, this paper aims to develop a framework that links a number of organisational factors to supplier value creation in product returns management. Its focus on the supplier involved in the return product management process is a distinctive contribution to the research literature.

The next section will review the background literature and this is followed by a discussion of the methodology used in the study. Key findings are then discussed in which a framework directed to value creation in product return management is proposed. Practical implications and limitations conclude the paper.

BACKGROUND LITERATURE

Research on returns management has concentrated on reverse logistics activities as exemplified by an early defining study (Dale S. Rogers & Tibben-Lembke, 1998) and summarised in several more recent review papers (Carter & Ellram, 1998; Dowlatshahi, 2000; Pokharel & Mutha, 2009). An integral part of supply chain management (Lambert & Cooper, 2000; Dale S. Rogers, Lambert, Croxton, & Garcia-Dastugue, 2002; Supply Chain Council, 2008), returns management subsumes the activities of reverse logistics and extends to gatekeeping and avoidance actions, both of which are aimed at cost minimisation. Gatekeeping involves the screening of products as they enter the reverse stream to ensure that only appropriate products are returned. Avoidance involves finding approaches that reduce items likely to be returned through such actions as user education, product design and improved product quality (Dale S. Rogers, et al., 2002).

Although reverse logistics has been defined as the management of the reverse flow of product for the "purposes of capturing or creating value or proper product disposal" (Dale S Rogers & Tibben-Lembke, 2001), the locus of value has centred on the product; the sources of value have concentrated on product disposal activities and value has been interpreted as the economic gains made from recycling, reuse and salvage (Bernon & Cullen, 2007; Pokharel & Mutha, 2009; Dale S Rogers & Tibben-Lembke, 2001). Little attention has been directed to examining how value might be created from the broader activities of product returns management.

A value perspective transcends a narrow cost view of business exchanges by considering benefits in addition to costs. Current literature points to value being a trade-off between, or the net of, benefits and costs (Blois, 2003; Gabbott, 2004; Khalifa, 2004; Lindgreen & Wynstra, 2005; Ulaga, 2003). When value is expressed in economic terms, it is usually expressed in terms of shareholder value as measured by return on investment (ROI) or economic profit (Economic Value Added or EVA) criteria (see for example Lambert & Burduroglu (2000), Lee and Lund (2003), Walters & Lancaster, (1999)). Shareholder value narrows the view to only one party in the supply chain and ROI tends to submerge any consideration of non-cost elements.

The concept of value in forward supply chain research is not new. For example, the value-added concept has been studied as a mechanism for supply chain integration (Fawcett & Fawcett, 1995) and as a means of creating competitive advantage (Walters & Lancaster, 1999). By contrast, value accruing through the returns process is an under-explored phenomenon within supply chain research. Studies on reverse logistics that explore value tend to focus on product flows, and the costs associated with these flows, specifically investigating issues related to material recycling (Huge Brodin & Anderson, 2008), the impact of reverse logistics on profitability, customer satisfaction and the environment (Jayaraman & Luo, 2007) and the need for speed in processing returns to minimise potential loss of value (Blackburn, Guide, Souza, & Van Wassenhove, 2004). Blackburn et al (2004) apply several concepts used in understanding forward supply chains to shed light on the design of reverse supply chains to maximise value. Specifically, the well known Fisher Model (Fisher, 1997) and the concept of the marginal value of time are used to recommend reverse supply chain designs.

Using evidence from seven case studies, Mollenkopf and Closs (2005) extend the analysis beyond costs alone to show the impact of effective product returns management on revenue stream and company assets. Evaluating the impact on revenue expands the discussion beyond logistics and illustrates the potential marketing advantage that can flow from effective returns management, such as enhanced customer perceptions of quality and goodwill that can accrue to organisations practising good corporate citizenship. The marketing connection is taken further by Jayaraman & Luo (2007), who suggest that a well managed returns program can be a marketplace differentiator, which could be leveraged to extract value. Recent studies highlight the need to consider internal firm integration if one is to fully understand the value implications of product returns (Mollenkopf, et al., 2011).

The foregoing studies suggest that value, or the benefits and costs from which value is assessed, is not necessarily tied to monetary units. Value can be derived from multiple sources: goods; services and revenue; knowledge; and intangible benefits (Allee, 2000). This paper draws on non-product related benefits and costs to explore the nature of value in product returns management.

METHODOLOGY

The study draws on a series of interviews to develop a framework for value creation in the process of product returns management. The organisations involved in the study were a major retailer, a third party logistics service provider (3PL) and two suppliers to the retailer. The retailer is a leading chain of consumer electronics and entertainment equipment in the Australian market. The 3PL has been engaged by the retailer to handle its product returns through a single centralised facility for the Australia-wide market. Both suppliers, affiliates of the parent companies, provide internationally known Japanese brands of high-end consumer electronics to the consumer market in Australia. The products include mobile telephones, digital cameras, hi-fi sound equipment, plasma and LCD TVs as well as small electric home appliances.

The research is exploratory in nature, aiming to understand what constitutes value in the reverse chains of product returns and how suppliers can capture value in the returns process. Value is a complex construct, variously understood by the diverse supply chain entities. Additionally, the returns process is complex, involving several departments within an organisation and other parties in the supply chain. Under these circumstances a qualitative case study methodology is suggested (Stavros & Westberg, 2009; Yin, 2003). Context-dependent knowledge as derived from case studies is central to understanding human behaviour in organisations (Flyvbjerg, 2006).

In-depth interviews and on-site visits to the various organisations were conducted. A total of nine participating executives were interviewed – three from the two suppliers, three from the retailer and three from the 3PL organisation. All were involved in the product returns management process. The in-depth interviews were open ended allowing participants to discuss broadly the returns process and their relationship with other supply chain entities. More detailed interview questions were used to follow up specific topics of interest. The interviews were recorded and the transcripts analysed to identify emerging themes. The interviews were supplemented with company supplied documentation and data available from corporate websites. Content analysis of these secondary sources provided additional insight into the organisations under study.

KEY FINDINGS

The study is limited to the consumer electronics sector. Retailer governance in the sector varies. There are fully corporate owned retail stores, independently owned retail stores operating under a single buying group banner and franchised stores. As in many retail sectors in many countries, big retailers in Australia tend to have the balance of power vis-a-vis- the suppliers. This was evident in this study in which the retailer had decided to move to a centralised returns management system using a 3PL. The decision to restructure the returns process was made solely by the retailer, which imposed the new process on its suppliers with little consultation.

To reduce costs, the retailer moved from what can be labelled a decentralised supply chain structure to the use of a centralised returned goods facility managed by a 3PL. Prior to the change to a centralised system, a decentralised system prevailed, in which each retail store had to manage its own returns, negotiating each transaction with each individual supplier within the terms and conditions of that supplier's policy. For the retail store staff, handling returns meant less time available for selling new product and more administrative activity, a costly exercise for the retailer. The priority for handling returns was obviously lower than the priority given to selling new product. Hence returns tended to languish at back-of-store, with associated holding costs, until staff had time to process the returns. In this decentralised environment the supplier returns procedure required the retailer to pay for the return freight, which led to a level of conflict when the retailer thought that the supplier should bear the cost of returning faulty goods.

In introducing the use of the 3PL, the retailer charged the supplier a fee for what it claimed were benefits that the supplier would gain from the use of the centralised 3PL returns centre. The retailer clearly had a value gain from the new procedure – the size of the fee charged the supplier ensured this in purely economic terms. Both suppliers, however, seemed to have difficulty recognising the full benefits side of the value equation and were unsure if there was a net value gain to them given the size of the fee they were being charged.

The use of a 3PL interposes an intermediary between the supplier and the retailer. As a result, the supplier perceived a loss of control over the returns process and a distancing from its customer (the retailer). Additionally, there was a perceived higher level of returns.

The supplier believed the gate-keeping function was now less effective as it thought that the retail stores were relaxing their vigilance in screening returns, finding it more expedient to pass the task to the 3PL. The supplier also believed that the 3PL too readily accepted the assessment of the retail staff and returned the product to the supplier rather than question the retail store's assessment and return the product back to the store.

These perceptions seem to have arisen from an inadequate performance measurement system. An effective system would have allowed an objective assessment of the level of returns to be made. There was certainly a larger volume of products being returned per shipment due to the consolidation of returned product, which led to a freight saving because of freight consolidation – a benefit for the supplier.

The 3PL has provided the retailer appropriate technology, information systems, strategic advice, valuable procedural experience and benchmarking data. Although this has contributed directly to value creation for the retailer, benefits have also flowed to the suppliers. Additionally, the 3PL has established product testing operations for a number of suppliers in the returns centre to allow supplier staff to test products and hence minimise unnecessary product movements. The 3PL seems to be playing a mediator role between supplier and retailer. Table 2 summarises the costs and benefits of the centralised system as they apply to the supplier.

Value Dimension	***Supplier***
Costs:	• Fee to Retailer for managing returns to recompense for cost of implementing centralised returns process though a 3PL. • Perceived loss of control over returns. • Perceived higher level of returns especially of NFF products.
Benefits – Tangible:	• Lower administrative costs (fewer transactions and single contact with Retailer). • Transport savings through consolidation of returns. • Improved condition of returned products and packaging giving ability to reuse or resell greater proportion of returns. • Centralised testing operations at 3PL returns centre.
- Knowledge:	• Aggregated data on returns and feedback from the Retailer and 3PL on product defects, functionality and usability useful to improve product design and ultimately returns avoidance. • Better ability to identify poor performing products.
- Intangible:	• More effective gate-keeping of product returns by Retailer. • Consumer advice (through gate-keeping function) by Retailer store staff enhances product value. • Retailer's consumer returns policy enhances Supplier brand equity. • Centralised returns process enables more clarity and visibility regarding returns and provides basis for closer relationship with Retailer.

Table 2: Value relationships (costs & benefits) Supplier

A value perspective transcends a narrow cost view of product returns by considering benefits as well as costs. As discussed above, such benefits may be tangible and intangible. What emerges from the interview data is the suggestion that a number of variables interact to eventually create value from product returns for the supplier. An organisation's strategic priorities will set the stage for its level of focus on product returns management. This is to be gained from knowledge about the impact of returns from an effective performance measurement system. A performance system is able to objectively identify and evaluate the impact of product returns on organisational benefits and costs and hence value (Coronado Mondragon, Lalwani, & Coronado Mondragon, 2011). Appropriate returns policies and procedures can only be effectively developed and administered in an organisation in which marketing, sales, operations and finance are integrated. The importance of marketing and operations integration to create customer value from product returns has been demonstrated recently (Mollenkopf, et al., 2011).

The 3PL, although a service provider to the retailer, has a bearing on the value extracted by the supplier: the 3PL delivers many of the knowledge and intangible benefits gained by the supplier.

Value extraction is a zero sum game. In this study, the implementation of a centralised returns process through a 3PL was dictated by the retailer who also determined the fee to charge the supplier for the 3PL services. Although there are benefits to all the parties in the supply chain in this situation and although the parties ultimately might be satisfied with the outcomes, nonetheless, the power asymmetry in favour of the retailer meant that it could unilaterally set the fee charged or deny the supplier some potential benefits. The power imbalance in the relationship meant that the value the supplier could extract was limited.

A framework as shown in Figure 1 is proposed. It highlights the relationship of internal factors in the process of value extraction. It also incorporates the mediator role of the 3PL in delivering benefits and the role of power balance in the supplier's ability to extract value from product returns.

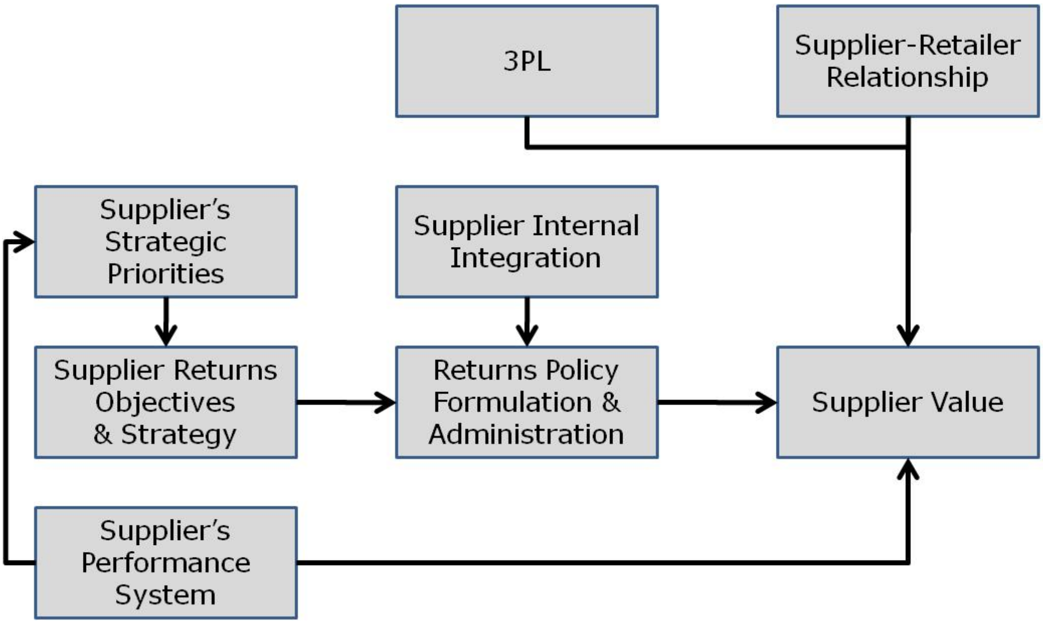


Figure 1: Supplier Value Creation Framework for Product Returns

CONCLUSIONS, IMPLICATIONS AND LIMITATIONS

As observed by Mollenkopf et al (2011) in their study on customer value creation from product returns, "future research also needs to more fully address value that accrues to the supplying firm." This study has been one of a number of studies addressing that need (Dapiran & Mollenkopf, 2010; Mollenkopf & Dapiran, 2007).

The findings show that value is a complex construct that includes elements beyond visible financial gains. Suppliers are able to create value from a number of benefit elements. In this supply chain in which a retailer engaged a 3PL to create a centralised reverse chain, it seems that the benefits gained by the supplier are in part being mediated by the 3PL. The power relationship between supplier and retailer also has a bearing on value creation. These external factors along with internal supplier variables comprise the proposed value creation framework.

The framework presented goes beyond the conventional approach of treating the value of managing product returns as part of resource minimisation, pollution and waste reduction. Exploration of value in product returns in this context is a contribution to theory development.

Moving the understanding of product returns management from a cost minimisation exercise to one that exposes its value potential offers an avenue for suppliers to effectively manage the process. The proposed framework offers a blueprint for suppliers to leverage the resources and capabilities of all parties involved in the product return process to extract value.

The framework presented in this paper is based on limited case data and so must be seen as tentative. This is an early exploratory stage of a multi-stage research stream that includes additional single-case and dyadic case studies of supplier-retailer dyads. The use of third party logistics service providers in managing product returns suggests a further dimension in this study. An in-depth triadic case study (supplier-retailer-3PL) is under way to explore, develop and test the framework presented here.

REFERENCES

Accenture. (2007). *Big Trouble with No Trouble Found: How Consumer Electronics Firms Confront the High Cost of Customer Returns*: Accenture.

Allee, V. (2000). Reconfiguring the value network. *The Journal of Business Strategy, July/August*, 36-39.

Bernon, M., & Cullen, J. (2007). An integrated approach to managing reverse logistics. *International Journal of Logistics: Research and Applications, 10*(1), 41-56.

Blackburn, J. D., Guide, V. D. R. J., Souza, G. C., & Van Wassenhove, L. N. (2004). Reverse Supply Chains for Commercial Returns. *California Management Review, 46*(2), 6-22.

Blois, K. (2003). Using value equations to analyse exchanges. *Marketing Intelligence & Planning, 21*(1), 16-22.

Carter, C. R., & Ellram, L. M. (1998). Reverse logistics: a review of the literature and framework for future investigation. *Journal of Business Logistics, 19*(1), 85-102.

Coronado Mondragon, A. E., Lalwani, C., & Coronado Mondragon, C. E. (2011). Measures for auditing performance and integration in closed-loop supply chains. *Supply Chain Management: An International Journal, 16*(1), 43-56.

Dapiran, G. P., & Mollenkopf, D. A. (2010). *Aligning Supplier-Retailer-3PL Product Return Processes: a Triadic Case Study* Paper presented at the Proceedings of the 8th International Meeting on Logistics Research.

Dietl, H., Royer, S., & Stratmann, U. (2009). Value Creation Architectures and Competitive Advantage: Lessons from the European Automobile Industry. *California Management Review, 51*(3), 24-48.

Dowlatshahi, S. (2000). Developing a theory of reverse logistics. *Interfaces, 30*(3).

Fawcett, S. E., & Fawcett, S. A. (1995). The firm as a value-added system: integrating logistics, operations and purchasing. *International Journal of Physical Distribution & Logistics Management, 25*(5), 24-42.

Fisher, M. L. (1997). What is the Right Supply Chain for your Product? *Harvard Business Review, 75*(1), 105-116.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*(2), 219-245.

Gabbott, M. (2004). Chapter 2: Defining value. In M. Gabbott (Ed.), *Introduction to marketing: a value exchange approach* (pp. 28-71). Frenchs Forest: Pearson Education Australia.

Horvath, L. (2001). Collaboration: the key to value creation in supply chain management. *Supply Chain Management: An International Journal, 6*(5), 205-207.

Huge Brodin, M., & Anderson, H. (2008). Recycling calls for revaluation. *Supply Chain Management: An International Journal, 13*(1), 9-15.

Jayaraman, V., & Luo, Y. (2007). Creating competitive advantages through new value creation: a reverse logistics perspective. *Academy of Management Perspectives*(May), 56-73.

Khalifa, A. S. (2004). Customer value: a review of recent literature and an integrative configuration. *Management Decision, 42*(5), 645-666.

Lambert, D. M., & Burduroglu, R. (2000). Measuring and selling the value of logistics. *The International Journal of Logistics Management, 11*(1), 1-17.

Lambert, D. M., & Cooper, M. C. (2000). Issues in Supply Chain Management. *Industrial Marketing Management, 29*(1), 65-83.

Lee, J., & Lund, M. (2003). *Strategies to optimize return on investment (ROI) through effective reverse supply chain programs.* Paper presented at the IEEE International Symposium on Electronics and the Environment

Lindgreen, A., & Wynstra, F. (2005). Value in business markets: What do we know? Where are we going? *Industrial Marketing Management, 34*(7), 732-748.

Mollenkopf, D. A., & Closs, D. J. (2005). The Hidden Value in Reverse Logistics. *Supply Chain Management Review*(July/August), 34-43.

Mollenkopf, D. A., & Dapiran, G. P. (2007, 8-10 July). *Closed loop supply chains: a retailer's perspective.* Paper presented at the 12th International Symposium on Logistics, Budapest, Hungary.

Mollenkopf, D. A., Frankel, R., & Russo, I. (2011). Creating value through returns management: Exploring the marketing-operations interface. *Journal of Operations Management, 29*(5), 391-403.

Pokharel, S., & Mutha, A. (2009). Perspectives in reverse logistics: A review. *Resources, Conservation and Recycling, 53*(4), 175-182.

Pollock, B. (2010). *Reverse logistics: driving improved returns directly to the bottom line*. Boston, MA: Aberdeen Group.

Rogers, D. S., Lambert, D. M., Croxton, K. L., & Garcia-Dastugue, S. J. (2002). The returns management process. *International Journal of Logistics Management, 13*(2), 1-18.

Rogers, D. S., & Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of Business Logistics, 22*(2), 129-148.

Rogers, D. S., & Tibben-Lembke, R. S. (1998). *Going Backwards: Reverse Logistics Trends and Practices*. Reno, NV: Reverse Logistics Executive Council.

Stavros, C., & Westberg, K. (2009). Using triangulation and multiple case studies to advance relationship marketing theory. *Qualitative Market Research: An International Journal, 12*(3), 307-320.

Supply Chain Council. (2008). Supply Chain Operations Reference-model: SCOR Overview. Washington, DC: Supply-Chain Council.

Tuominen, M. (2004). *International Journal of Retail & Distribution Management, 32*(4), 178-189.

Ulaga, W. (2003). Capturing value creation in business relationships: A customer perspective. *Industrial Marketing Management, 32*(8), 677-693.

Walters, D., & Lancaster, G. (1999). Value-based marketing and its usefulness to customers. *Management Decision, 37*(9), 697-708.

WERC. (2007). *Reverse logistics: backward practices that matter*. Houston, TX: Warehousing Education and Research Council.

Yin, R. K. (2003). *Case Study Research: Design and Methods* (Revised ed. Vol. 5). Thousand Oaks, CA: Sage Publications, Inc.

IMPROVING COORDINATION OF HUMANITARIAN RELIEF SUPPLY CHAINS: THE 2010 HAITIAN EARTHQUAKE CRISIS

Laura Lamlenn[1] (corresponding author) and Christos Braziotis
Nottingham University Business School
Jubilee Campus, Wollaton Road,Nottingham, NG8 1BB, UK.
E-mail: lamlenn.laura@live.com Tel: +44(0)1159504096

Keywords: Coordination, Relief chain, Humanitarian, Supply chain management, Crisis, Critical success factors

Category: Supply Chain Management

INTRODUCTION

Supply chains (SC) are an essential part of any organisation because "*they exist to make a product or provide a service that someone values*" (Bozarth and Handfield, 2006, p. 544). For commercial SCs, their effective management aims to add value to the customer and consequently to the company in the form of profits and customer loyalty (Chopra and Meindl, 2009). However, in the humanitarian environment, effective management is very difficult to achieve because the conditions are highly uncertain, making the effective coordination of relief activities difficult. Several authors have pointed out the characteristics of a relief environment (e.g. Oloruntumba and Gray, 2002; Kovacs and Spens, 2007; Balcik *et al.,* 2009), but Beamon (2004) offered a comprehensive summary of these characteristics as follows:

i. Relief chains operate under high stake: usually life or death situations thus speed is essential to save as many lives as possible.
ii. Relief chains operate on voluntary contributions of resources especially finance and labour which are generally accumulated once a crisis occurs.
iii. It has a limited pool of experienced personnel which is characterised with high staff turnover in relief agencies.
iv. The conditions in which relief chains operate are highly unpredictable: for example the location, timing and nature of the crisis cannot be known prior to the event so it is difficult to plan for.

In addition to the points above, Tomasini and Van Wassenhove (2009) pointed out that the final distribution is generally very difficult because transport infrastructures are often damaged by disasters, inexistent or insufficient to cope with the scale of need to satisfy the surge in demand caused by the disaster.

In relief chains, there are different stages of disaster planning: preparation, response and reconstruction (recovery): different amounts of resources and skills are used at each stage making the strategic requirement for each stage different (Kovac and Spens, 2007). Moreover, no single relief organisation has the necessary resources to deal with every stage's requirement, hence different combinations of organisations will be involved at each given stage and each of them have different strategic plans (Balcik *et al*., 2009). As such coordination between relief chains of participating Non-Governmental Organisations (NGOs) and other actors is essential to maximise the use of limited resources to meet the demands in a crisis situation.

COORDINATION RELATIONSHIPS WITHIN THE RELIEF ENVIRONMENT

Balcik *et al.* (2009) revealed that there is a two way coordination relationship within a relief environment: relationship between international relief actors and the private sector (philanthropic and commercial relationships) and relationship with local relief actors. Past

[1] Laura Lamlenn is a recent graduate of the Nottingham University Business School MSc in Supply Chain and Operations Management.

experiences from large scale disasters such as the Asian tsunami, Darfur crisis and hurricane Katrina have put the effectiveness of overall coordination of relief chains to the test. Yet, recent studies evaluating coordination efforts of relief organisations in crisis situations have shown that overall coordination has been and still is problematic (Balcik *et al*., 2009; Van Rossum and Kruckkert, 2010).

A recent case where the problem of poor coordination was highlighted mostly by the press was the case of the Haitian earthquake. On January 12th, 2010, at 4.53 pm, Haiti was hit by an earthquake of magnitude of 7.0, just 10 miles west of Port-au-Prince. In total it affected and displaced a population of over 3 million people excluding the estimated 222,700 (estimations by the Government as of June 2010) people that were killed (IASC, 2010). The last earthquake of this nature experienced by Haiti was about 150 years ago, in 1860 (Taft-Morales and Margesson, 2010). About 200 relief NGOs, such as the United Nations (UN), International Federation of the Red Cross (IFRC) and Oxfam, and 30 countries participated and/or contributed to the post-disaster response and recovery of Haiti (Disaster Accountability Project, 2010). Yet, despite the level of experience and repeated encounters between these relief organisations, effective coordination has been difficult to achieve: the coordination problems as will be seen later in this paper are similar to the ones experienced in the highly publicised 2004 Asian Tsunami with approximately 220,000 deaths with a wide range of relief NGOs and military actors (Mangan *et al*., 2008). Binder and Grunewald (2010) agree that this crisis and the performance of inter-agency coordination is similar to that of 2004 Asian Tsunami.

There are studies that have used management theories to suggest improvements for the management and coordination of relief activities in the field: for example, Beamon (1999) focused on performance measurement and Oloruntunba and Gray (2006) on Agile SC strategies. Both suggested that situations are different and lessons learnt cannot be readily applicable to another situation. Nevertheless, it has been argued (e.g. Power *et al.*, 2001, Petit and Beresford 2009) that concentrating on SC-related Critical Success Factors (CSFs) could help in improving coordination within a relief environment.

According to Pettit and Beresford (2009), CSFs are simply the variables identified within an organisation that can be influenced and managed and if properly done, could have a significant impact in the performance of that organisation within its industry. Availability and use of funding and resource in the relief environment form a vicious circle: Funding, resources and to some extent the workforce are voluntary, therefore there is a high need to be efficient. Relief organisations have to showcase their relief activities and achievements so that they can get more attention from the public and consequently more funding and resources. Petit and Beresford (2009) argued that in order to achieve efficiency, uncertainty needs to be eliminated from the environment. This is impossible within a relief environment, thus the need to identify and work on CSFs. Based on Pettit and Beresford (2009) seven main categories of CSFs applicable in relief environments can be identified. These CSFs, with the incorporation of other literature, are discussed below:

i. <u>Strategic planning:</u> Strategic management takes the view of an organisation as a whole and defines how an organisation fits into its business environment (Daft and Marcic, 2004). It could include corporate strategy, outsourcing, locations of distribution centres and effective use of organisation strengths. Without a clear strategic plan, a relief organisation can fail to fully achieve its potential such as efficiency and coordination. For example, after the 2004 Asian Tsunami, poor planning led to an ineffective response by most of the participating organisations (Fritz institute, 2005) Successful strategic planning will mean a better performance of other CSFs such as information, capacity and inventory management (Volz, 2005).

ii. Inventory management: Typically, inventory management in relief chains initially operates a push system (pre-positioning) in strategic storage locations before pull systems are implemented to get resources to the precise area of need (Whybark, 2007). Pre-positioned warehouses are usually located close to crisis-prone areas e.g. currently UNHRD has warehouses in 5 locations Ghana (Africa), Italy (Europe), United Arab Emirates (Middle East), Panama (Latin America) and Malaysia (South East Asia).

iii. Transport and capacity planning: Logistics makes up for about 80% of relief chain thus it is a very critical aspect of the relief chain (Long, 1997; Van Wassenhove, 2010). Transport planning will require determining the mode of transport (air, land or sea) depending on the locations of crisis, capacity utilisation, scheduling and maintenance (Pettit and Beresford, 2004). Unlike commercial organisations, the provision of transport facilities is very unstable and expensive because they are acquired at the last minute (Byman *et al.*, 2000). It will be more efficient,if it were planned for prior to a disaster. However, in emergency situations, relief agencies find themselves competing for transport and warehouse capacity which tends to drive local prices up as a response to market forces as demand exceeds supply.

iv. Information management and technology utilisation: Long and Wood (1995) argue that information management is the "single greatest determinant of success". The faster the information is disseminated, the quicker the response. This speed can be well acquired with the use of up-to-date technology which will facilitate real time dissemination of information in easy formats be it formal or informal. Real time communication *"... is the most important method of reacting quickly for effective coordination"* (Long, 1997). For example, during the early stages of the Asian Tsunami, more the 80% of communications were done by cell phone during the first weeks then later on by email. Different technologies can be used to communicate but it is important to find the right balance and compatibility, if not it may lead to problems such as bottlenecks, support failures and black holes.

v. Human resource management: Getting the right and trained personnel for human response will speed up response and will ensure maximum use of capacity and resources. Humanitarian staff capacity has 2 main components which affect the quality of a relief operation: the size of the "skilled and experienced" pool and the level of their skills (Richardson, 2006). Generally the levels of expertise in relief chains are low with a reported shortage of experienced staff (Emergency Personnel Network, 2003). This poses a major constraint in the rapid response to emergency situations.

vi. Continuous improvement and collaboration: It is recognised as the key differentiator of best practice in supply chain management (SCM) as it achieves integration and efficiency in logistics networks (Power *et al*., 2001). It involves sharing of information, resources and process integration.

vii. Supply chain strategy: Relief chains portray very strong characteristics of an SC where the supply has a short lead time and highly unpredictable demand (Oloruntoba and Gray, 2006).

As mentioned above, some studies have tried to use these SCM tools i.e. CSFs, performance measurement *etc.* to address coordination problems in relief SCs but none of them have used a case study approach. This paper will explore the concept of CSFs in relief chains in the light of the experiences of the United Nations (UN) coordinating the efforts of relief organisations working in Haiti during its recovery from the recent earthquake (January 12, 2010). Pettit and Beresford (2009) argued that the area of CSFs is very important in determining the success of an operation but have been poorly covered in the humanitarian sector. Therefore, this paper primarily aims to find ways to improve coordination efforts within Humanitarian SCs by focusing on the problems that affect relief chain CSFs. Our research aimed to identify the aspects that hinder successful relief chain management and thus coordination of response. As discussed earlier CSFs ensure success of relief chains; as such problems hindering them, hinder the success of operations. We also aimed to identify possible solutions that could be adopted for future use to reduce the impact of the problems identified.

METHODOLOGY

We followed a qualitative research approach, using a combination of secondary (online reports, online news broadcasts, websites and documents covering the events and aid distribution in Haiti) and primary sources (interviews and e-mailed questionnaires). This approach was chosen because it offers a greater opportunity to explore the nature of the problems faced during humanitarian operations in Haiti than a quantitative approach (Kumar, 2005), as it offers the opportunity to grasp elements and underlying reasons of the variation of a phenomenon that one is not aware of. The phenomenon under investigation in our research was the coordination between relief chains in the case of the Haiti crisis. Participants in the primary research included humanitarian specialists, to assess their first-hand experiences on the conditions in Haiti during their visits. The primary sources offered the opportunity to collect different points of view (achieving some degree of triangulation), the chance to gather expert suggestions for improvement areas and to validate the results. The questionnaire was emailed to employees of the United Nations Population Fund (UNFPA) New York office of 28 specialists and received a total of 15 responses (a response rate of 53.6%). Three relief specialists (a logistician and 2 population statisticians) from the same office were interviewed on their personal experiences during their visit to Haiti. The identity of the participants has to remain confidential. The interview was unstructured as questions evolved depending on the answer that was given for a specific question. The questions were directed towards their area of expertise and their overall experience on the field. The data collected from the questionnaire and interviews were reviewed frequently to check and clarify any inconsistencies in the responses. Some concepts and procedures of Strauss and Corbin's (1990) grounded theory were borrowed to present the findings as it offers a systematic and comprehensive way of representing the data gathered from the primary sources. The next section analyses the situation in Haiti in respect of Petit and Beresford's (2009) CSFs, and the following section covers the lessons and action strategies and a summary of the results.

PROBLEMS IDENTIFIED IN THE HAITI CASE

One of the aims of this paper was to find out the problems that affected the coordination of relief activities in Haiti, exploring them in the light of the CSFs:

a. Strategic and preparedness issues: Preparedness status of international relief organisations was considered strong as organisations such as the UN have prepositioned warehouses filled with basic aid stock (e.g. water, first aid kits and blankets). Conversely, national level of preparedness for an earthquake was very weak and nearly non-existent: this is not surprising because Haiti had not suffered such an earthquake for almost 150 years. In addition, the country's building standards were very poor and almost non-existent which resulted in serious damage of buildings and infrastructure, hindering transport and communication. Collaboration between national authorities, military and local actors was very important for the execution of aid projects and the security of relief workers and volunteers on the field. However, the interaction was described as "very slow" by one of the respondents, as there was a lot of red tape imposed by military agents for security reasons and a conflict of interest between both parties. Grunewald and Binder, (2010) explained that the poor collaboration initiatives resulted from the lack of trust in the whole system and with each other (locals and foreigners). This led to withholding information and local knowledge which may have been vital for these relief agencies to work effectively. In addition, being a dominantly French and Creole speaking country, Haiti has a different culture and language when compared to the neighbouring Latin American countries. One respondent pointed out that Haiti did not have much association with the neighbouring countries which would have improved the immediate response and in the long run the development status of the country.

b. Collaboration and relationship management: Information sharing appeared as an issue within the first week of the crisis. However, information sharing platforms such as *Ushandi* and *Sahana* were created and used by rescue workers to track the situation of victims in various camps and monitor the stock levels in numerous established warehouses (Raftree, 2010). Coordination between participating relief organisations were managed by the UN cluster systems. There are 8 clusters: Water, Sanitation and Hygiene (WASH), Logistics, Camp Co-ordination and Management, Emergency shelter, Emergency telecoms and IT, Health, Nutrition, Early recovery and Protection cluster. Binder and Grunewald (2010) had a few criticisms on the cluster approach: they believed it was mainly a top-down implementation which completely disregarded the functional local coordination structures, leadership structure was weak, and there was a very weak link between various clusters and the Humanitarian coordinator. One of the interviewees recognised accountability as one of the main problems particularly because the Humanitarian coordinator had limited experience dealing with humanitarian operations of this magnitude, so delegation and acquisition of information was problematic. Most of the respondents brought up the issue of trust: the country had suffered years of dictatorship and corruption so the locals found it hard to trust foreigners and often withheld valuable information that could help with operations.

c. Procurement and inventory management: As a result of the earthquake, procurement in the local markets was not possible. One participant suggested that even if it were possible, it would have been very expensive. As such, international procurement was the best means possible; the proximity of large international markets such as the US, Brazil, and Mexico, made procurement relatively easy and straight forward. However, this turned out to be very expensive due to price competition and bidding by organisations as they are running on donations. As pointed out by one interviewee, the increase in demand for basic relief products that could be sourced from neighbouring markets caused increase in prices in these countries. Donations in kind are one of the ways relief agencies get supplies and they are widely encouraged. Nevertheless, sometimes donations sent by the general public are not suitable for use and simply increase the work load for inventory management because they need to be sorted. This is a common problem and was encountered during the 2004 Asian Tsunami when aid workers in Sri Lanka had to deal with the organisation and sorting of stiletto shoes, winter coats and expired cans of salmon which, although sent with good intentions, were not suitable for the needs of the displaced population. In the Haiti case, the logistics cluster made instructions available online on the kind of goods that could be donated. In addition, the inventory management technology was not as sophisticated as those used in previous crisis for example previous earthquakes such as the one in Salvador in 2001, sophisticated inventory management systems such as SUMA (by FUNDESUMA, an implementing partner of the Pan-African Health Organisation and the World Health Organisation) were put in place at the airport in El Salvador to track incoming goods and match them against appeals. This ensured greater visibility of in-kind donations that helped the response effort to define future procurement needs (Van Wassenhove *et al.*, 2003). Nevertheless, it resulted in bottlenecks and severe delays within some relief SC such as in PROMESS warehouses for the World Food Programme (WFP) and UNICEF (scms.pfcm.org, 2010).

d. Technology and Information management: Given that Haiti was a less developed country with a struggling economy, the technology level was not as good as that of the developed countries and agencies that came in to assist after the earthquake. It was almost impossible to use high gear technology for the transfer of information and storage of data especially during the first weeks of assessments of the situation by UN employees. The power systems were down resulting in the loss of electricity supply for a couple of weeks and the phone systems were severely compromised (Seybold, 2010). The main problems experienced were storage, coordination and dissemination of information. Though there was the use of information sharing platforms, one of our interviewees described information management as "very disorderly". Because of the multiplicity of actors involved, there were so many multi-sectored assessments which were done in parallels rather than coordinated with other NGO's involved.

e. Human resource management: One of our interviewees noted that because of the transport problems, most of the volunteers were acquired locally, and therefore the level of expertise was very low though cheap. Therefore they required a lot of direction from those in charge to get the work done. The UN collaborated with local volunteering groups, such as the Bureau of Citizen volunteers (BIC), but as mentioned earlier, coordination problems affected the harmonisation of volunteer efforts and the dissemination of information. In addition, unsolicited volunteers posed problems for human resource management such waste of time, resources and the capacity to cater for their stay and security.

f. Transport and capacity planning: For co-ordination purposes, this area was managed by the logistics cluster and is chaired by the WFP. The logistics system is supported by the Humanitarian Supply Management System (SUMA). One of the respondents described capacity planning as "a nightmare" as there was little infrastructure for warehousing and logistics management. Few warehouse infrastructures such as those of PPROMESS which survived the earthquake were seriously overcrowded with medical supplies from several participating agencies such as USAID, WHO and the Clinton Foundation (scms.pfcm.org, 2010). This led to the breakdown of the information and inventory management systems of the warehouse and eventually posed as a bottleneck to quick and efficient response (scms.pfcm.org, 2010). Conversely, most agencies such as Oxfam used their warehouses overseas (Bicester, Oxfordshire, UK) and simply transported the supplies into the country and distributed them straight away (news.bbc.co.uk, 2010). Despite this initiative,, Martijn Blansjaar, Oxfam's head of logistics admitted that capacity management and transportation to Haiti was very straight forward but the real problems faced was in distribution to the affected population within Haiti itself (news.bbc.co.uk, 2010). Land transport was the most popular means of last mile distribution as the airport capacity was seriously restricted due to damage and a great influx of flights with supplies. There was a problem with high levels of bureaucracy at the land borders that held trucks with supplies for days thus causing disruption in the SC. The logistics cluster released a briefing paper aimed to provide guidance on required documents, procedures and labelling for deliveries. However, one interviewee revealed that the U.S forces had taken control of the borders and airports and had their own concerns for security. But it appears that with the rush to get supplies into Port-au-Prince, most of these documents did not come in on time for dispatch, coupled with the lack of space to hold these goods before delivery. This caused trucks to be held at the border for days leading to drivers giving up by either returning with the delivery, distributing them to the poor in border towns or resorting to bribing the officials (MSNBC, 2010).

g. Continuous improvement: It is evident that the international organisations operating in Haiti use performance measures because most of them release audit reports illustrating their performance for a certain period on their websites e.g. Save the children, UNICEF, USAID. However there is not enough effort to keep this performance tools operating after the crisis situations. One interviewee explained that performance measures, if present in the organisations, are entirely for coordination within that organisation and not assessing the performance of coordination with other organisations. This has contributed to the problem with parallel assessments because humanitarian personnel are loyal to their agencies first and are primarily interested in the incentives that come with meeting the requirements of a performance measure. As a means of control and improvement, the Office for the Coordination of Humanitarian Affairs (OCHA) got nearly all the clusters to do strengths and weaknesses analysis at the end of each emergency response as an initiative to improve accountability (Binder and Grünewald, 2010). Nothing was said about this being documented as lessons learned. One participant explained that individual reports are required from specialist after every field mission, but there is no formal system that exists within the UN agencies to generate a coordinated documentation of lessons learned. One of the respondents specifically pointed out the fact that humanitarian bodies need to learn from their mistakes suggesting that thorough strategic planning with the inclusion of lessons learnt is not really present in humanitarian organisations.

h. Supply chain strategy: There was no particular information about the type of SC strategy used by relief organisations in Haiti. Whatever the case, it is difficult to identify the problems with each of the organisations' strategy because they are good at what they do from experience. The respondents did not comment on the status of SC strategy but one interviewee suggested that logistics was undermined in strategic planning in some UN agencies which in the case of the humanitarian sector implies a major part of SC strategy.

SUGGESTED ACTION STRATEGIES & LESSONS LEARNED

The problems examined above only highlight those experienced in the case of Haiti and as gathered from the interviews, situations vary and so will the problems. However, the lessons that can be learnt from the Haiti case should be considered for all other natural disasters too because they focus on the basic SC processes present in most humanitarian organisations and on some elements necessary to make the operation of these organisations on the field easier.

i. Call for better preparedness: The Haitian government was heavily criticised for their lack of preparedness especially as they failed to adhere to the warnings of an earthquake (Holderman, 2010). Countries could improve preparedness by: improving constructions standards, increasing disaster awareness and involve neighbouring countries. In Haiti, debris and wrecked infrastructures were a hindrance to the performance of other CSFs particularly increasing the problem of access. Strict construction standards should be set out for construction engineers and they should be a government inspection team in place for the inspection of new buildings to ensure that standards are met. Constructions standards should be suitable for the kind of disaster the area is most exposed to e.g. Chile's strict building codes follow a seismic design with enforced concrete columns and steel frames. As a result of these strict building codes, the resulting death toll was less than 1% than that of Haiti (Lafsky, 2010). For increased disaster awareness, the government can team up with local NGOs and schools to provide training lessons for survival as well as provide survival kits for each home. This should increase the chances of survival and somehow provide basic training for potential volunteers. Finally, respondents of the questionnaire believe that involving neighbouring countries could improve preparedness levels and create stronger network for quicker response after a crisis.

ii. Better strategic planning on the part of relief organisations: According to the contributions by the respondents and the interviewees, contingency planning should be taken by all countries especially those with a high risk factor for a natural disaster. It is recommended that concerned governments should liaise with international and local partners to build comprehensive national contingency plans. One interviewee stressed that these plans need to be checked and updated regularly for feasibility. Also, most of the major contributors of international response pledge military assets and personnel. But military forces and relief organisations have conflicting interests: fighting and security versus peace and development. To control the conflict of interest, strategic planning could include the creation of guidelines and ensure that these military actors are aware of their roles and responsibilities and are willing to follow the guidelines (accreditation) considering that military forces come from different parts of the world. Finally, one interviewee pointed out that the logistics department is undermined and treated as a "back-of-office" job in most relief agencies, especially in some UN branches such as UNFPA. Recognising its importance and including it in strategic decisions will prevent a "fire fighting" situation where logistics is sorted out in the last minute (Van Wassenhove, 2006).

iii. The need for more experienced personnel: A study by Richardson (2006) revealed that agencies normally prefer to use staff with prior experience of response to emergencies. However, the pool of experienced personnel is diminishing within the sector having a very high turnover of employees (Emergency Personnel Network, 2003). This pool of talent can be maintained by involving younger professionals into the field. This can be done by raining interest for the industry from education level through workshops, presentations and internship opportunities. Respondents also recommended frequent ad-hoc training to incorporate lessons learned in an employee's skills set. One interviewee believes this will bring resident head coordinators of vulnerable countries up to speed with the challenges in filling the role of the humanitarian coordinator.

iv. Better collaboration initiatives: The cluster approach can be made more inclusive of already established collaboration systems as well as local NGs and the government for local knowledge and expertise. Accountability can be improved by clearly defining the roles and responsibilities of participating organisations as well as implement division of labour or partnership where two or more organisations appear to have similar capabilities to carry out a role e.g. case of MINUSTAH and OCHA in Haiti. A clearer definition of roles should map out lines or responsibility and thus accountability. After the disintegration of the cluster, follow up forums or if possible meetings can be encouraged to reassess roles and redefine responsibilities when necessary depending on feedback from participating organisations.

v. Sustainable improvement initiatives: The interviews revealed that there is no formal system for the documentation of lessons learnt in their office. A formal compulsory system would enable the participation and encourage the different UN agencies to learn from each other's experiences. Furthermore, introducing inter-agency coordination performance measures will help encourage collaboration and the management of these complex relationships. It will also promote repeated interaction even outside a crisis situation (Power *et al*., 2001).

vi. Explore and exploit relationships with the private sector: The private sector contributed to the response in Haiti by providing basic resources such as water, food medication and even aircrafts to transport relief goods to Haiti e.g. British Airways, Air France/KLM, UPS and DHL provided planes and warehouse capacity to UNICEF and WFP. Still, Sir John Holmes, the UN Under-Secretary-General and Emergency Relief Coordinator (USG/ERC: before 7th September, 2010), criticised the UN for not exploiting these relationships (Philanthropic and commercial) for strategic purposes such as technology development and logistics capacity planning (Redr.org, 2009). There are other opportunities in the SC where their participation will boost capacity, e.g. use services of 4th party logistics (4PL) providers, collaboration to produce and supply suitable lodging supplies that withstand adverse conditions such as rains and strong winds. This should improve capacity and facilitate the operations of humanitarian organisation on the field.

This paper focused on finding the problems faced and the suggested action strategies in the Haiti case. Evidence was gathered in the form of key themes that emerged from the research, as discussed above. The following figure 1 indicates the aspects of the analysis in the form of an action strategy model to coordinate response within a humanitarian SC that describes the case under investigation. With the use of Strauss and Corbin's (1990) basic open and axial coding procedures, keywords provided by the respondents and the interviewees were gathered and represented under the sections 'Problems Faced' and 'Suggested Action Strategies'.

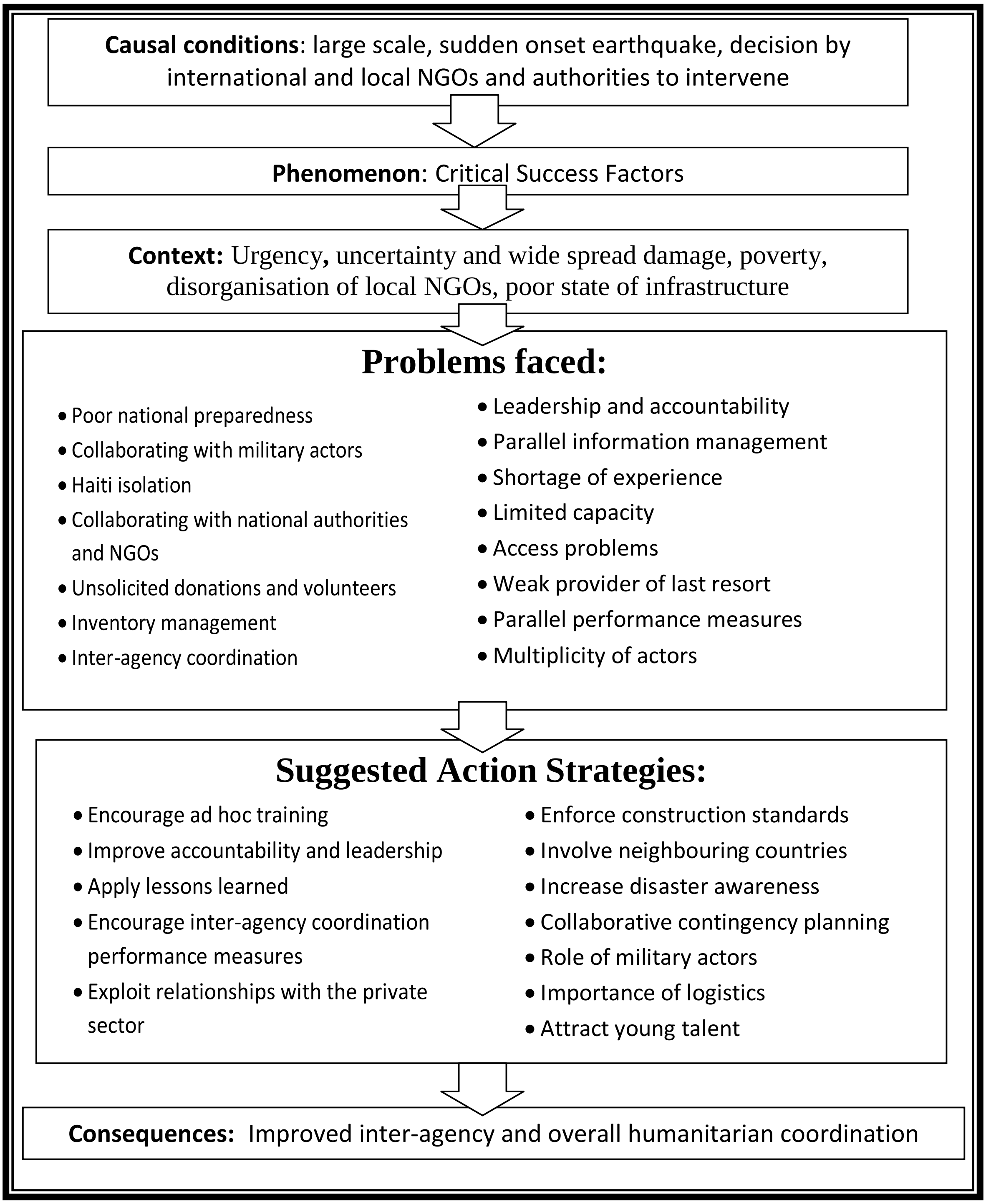


Figure1: Summary of final results including problems and suggested action strategies

According to Volz (2005), successful strategic planning will enhance the performance of other CSFs. But this did not seem to be the case with Haiti as problems were faced with each of the CSFs. Based on the research evidence, the analysis of the situation led to suggested action strategies, as indicated above, which should be considered in future strategic planning both on the part of relief organisations and the authorities concerned (e.g. government of high risk countries). Taken into account, they should enhance the performance of other CSFs once in operation.

CONCLUSIONS

Using the CSFs provides a structured framework to evaluate the problems faced, therefore helping facilitate the building and implementation action strategies because the problems are categorised under each factor. The practical implications of this research go beyond just coordination within an organisation’s supply chain; they extend to inter-agency coordination and vulnerable country preparedness to lessen damage and speed up recovery. The lessons drawn from this case can be applied to other crisis situation as they are focused on the standard processes that exist in every supply chain hence the use of CSFs to evaluate these problems.

The analysis of the coordination problems experienced during the Haiti Crisis has drawn attention to 3 main causes: Poor preparedness and strategic planning on the part of Haitian government and UN agencies, lack of experienced personnel, and unclear accountability lines mainly due to poor planning and preparedness, multiplicity of actors and few experienced personnel. These were the main points around which the lessons to be learned were drawn. The keywords from the responses were all centred on improving national preparedness, improving UN strategic planning, the need for more experienced personnel, improving overall humanitarian coordination and exploiting missed opportunities with the private sector.

This research has some limitations: firstly, it focused mainly on the operations of the UN agencies since they were the leading organisation in this crisis and most of the secondary information available pertained to them. Secondly, although some degree of triangulation was sought by including in the research people from different departments and hierarchical positions with the UN, the sample population remains small (15 respondents and 3 interviews). Further research on recent crisis situations and the lessons to be learned is encouraged. Especially in areas such as inter-agency performance measures and collaborative strategic planning between authorities of high risk countries and key playing relief organisations like the UN or IFRC as a means of enhancing national preparedness.

REFERENCES

Aleccia J., (2010), “Disaster Do-gooders can actually hinder help”, [Press release] 23/01/2010, Available at: http://www.msnbc.msn.com/id/34958965/ns/world_news-haiti_earthquake/ accessed 06/05/2010, 13:26

Baldini, L., (2010), “Tracking aid from UK to earthquake-hit Haiti”, BBC News [Online] 22/01/2010, available at: http://news.bbc.co.uk/1/hi/uk/8473786.stm accessed 05/05/2010, 11:15

Beamon, B.M., (1999), “Measuring supply chain performance”, International Journal of Operations and Production Management, 19, 275–292

Beamon, B.M., (2004), “Humanitarian relief chains: issues and challenges”, paper presented at the *34th International Conference on Computers & Industrial Engineering*, San Francisco, CA, November 14-16

Bozarth, C., and Handfield, R., (2006), *Introduction to Operations and Supply Chain Management*, Pearson Prentice Hall Education Inc.

Binder, A. and Grünewald, F., (2010), “Haiti”, Inter-Agency Standing Committee (IASC) Cluster Approach Evaluation, 2nd phase, country study, April 2010

Balcik, B., Beamon, B.M., Krejci, C.C., Muramatsu, K. and Ramirez,M., (2009) "Co-ordination in Humanitarian relief chains: practices, challenges and opportunities", *International Journal of production Economics*, Vol. 126, pp. 22-34

Chopra, S. & Meindl, P. (2009), "*Supply Chain Management: Strategy, Planning and Operation*", 4th edition, Prentice Hall

Engebawry, M., (2010), "Haiti Earthquake: Lessons Learned for Reducing Risks in the United States", Available at: http://hubpages.com/hub/haiti-earthquake-lessons-learned-for-reducing-risks-in-the-united-states, last accessed: 12/05/2011
Fritz Institute (2005), "Logistics and the Effective Delivery of Humanitarian Relief", Fritz Institute, San Francisco, CA, p. 12.

Hoffman,C. A. and Hudson, L., (2010), "Military responses to natural disasters: last resort or inevitable trend?", available at: http://www.odihpn.org/report.asp?id=3030 , Humanitarian Exchange Magazine, Issue 44, September 2009

Holderman, E., (January 14, 2010) "Three Early Lessons from Haiti"**,** available at: http://www.emergencymgmt.com/emergency-blogs/disaster-zone/Three-Early-Lessons-from.html, Emergency management.com

Inter-Agency Standing Committee, (2010), "Response to the Humanitarian Crisis in Haiti", IASC: Haiti Earthquake Response, 6-Month Report, available at: www.humanitarianinfo.org/**iasc**/downloaddoc.aspx?docID=5366&type

Kovacs, G. and Spens, K.M. (2007), "Humanitarian logistics in disaster relief operations", *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 2, pp. 99-114

Kumar, R., (2005), *Research Methodology: A Step-by-step Guide for Beginners,* 2nd edition, Sage publications Ltd

Lafsky, M.,(March,1,2010) The Power of Building Codes: death toll less than 1% that of Haiti, Available at: http://www.infrastructurist.com/2010/03/01/the-power-of-building-codes-chile-death-toll-less-than-1-that-of-haiti/

Long, D.C. (1997), "Logistics for disaster relief: engineering on the run", *IIE Solutions*, Vol. 29No. 6, pp. 26-9

Long, D.C. and Wood, D.F. (1995), "The logistics of famine relief", *Journal of Business Logistics*, Vol. 16 No. 1, pp. 213-39

Mangan,J., Lalwani, C. and Butcher, T., (2008), "*Global Logistics and Supply Chain Management"*, John Wiley and Son, Ltd

Olorotunba, R. and Gray, R. (2002), "Logistics for humanitarian aid: a survey of aid organisations", *Proceedings of the 7th Logistics Research Network Conference*, Birmingham, September

Olorotunba, R. and Gray, R. (2006), "Humanitarian aid: an agile supply chain?", *Supply Chain management: an international journal*, Vol. 11, No. 2, pp. 115-120

Power, D.J., Sohal, A.S. and Rahman, S-U. (2001), "Critical success factors in agile supply chain management", *International Journal of Physical Distribution & Logistics Management*, Vol. 31 No. 4, pp. 247-65

Pettit, S.J. and Beresford, A.K.C. (2009), "Critical success factors in the context of Humanitarian supply chains", *International journal of physical distribution and logistics management*, Vol. 39, No. 6, pp. 450-468

Redr UK News, (04/12/2009), UN Emergency Coordinator calls on the humanitarian community to engage with the private sector, available at: http://www.redr.org.uk/en/Newsroom/Latest_News.cfm/un-emergency-coordinator-calls-on-the-humanitarian-community-to-increase-engagement-with-the-private

Richardson, F., (2006), "Meeting the demand for skilled and experienced humanitarian workers", *Development in Practice*, Volume 16, Nos. 3&4, Oxfam GB, Rutledge Publishing, pp. 334-341

Seybold, P., (2010) "Innovations in Haitian Relief & Rescue: Global/Local Coordination for Haitian Relief and Rescue Efforts", 21/01/2010, available at: http://outsideinnovation.blogs.com/pseybold/2010/01/innovation-in-haitian-relief-rescue.html last accessed:07/05/2011,

Supply Chain Management Systems Haiti, 2010, "In Haiti, helping PROMESS regain its footing after the earthquake" http://www.scms.pfscm.org/scms/where/ht last accessed 07/05/2011,

Taft-Morales, M. and Margesson, R., (2010) "Haiti Earthquake: Crisis and Response", Congressional Research Service Report for Congress, January 15th, 2010

Tomasini R.M. and Van Wassenhove L.N. (2009), "*Humanitarian Logistics*",INSEAD Business Press series, Palgrave Macmillan

Van Rossum, J., and Krukkert, R., (2010), "Disaster management solutions in Indonesia: Logistical Coordination and Cooperate to Create Effective Relief Operations", *Jurnal Teknik Industri*, Vol. 12, No., 25-32

Van Wassenhove, L.N. (2006), "Humanitarian aid logistics: supply chain management in high gear", *Journal of the Operational Research Society*, Vol. 57, pp. 475-89

Van Wassenhove, L.N., Martinez, A.J.P and Stapleton, O., (2010), An analysis of the Relief Supply Chain in the first week after the Haiti Earthquake, INSEAD humanitarian Research Group

Volz, C., (2005), "Humanitarian coordination in Indonesia: an NGO viewpoint", Forced Migration Review July, 26–27

Whybark, D.C. (2007), "Issues in managing disaster relief inventories", International *Journal of Production Economics*, Vol. 108 Nos 1/2, pp. 228-35.

THE CHANGE OF THE LOGISTICS SERVICE PROVIDER´S DECISION ON MAKING ROLE IN MACHINERY INDUSTRY
- FROM RESOURCE PROVIDER TO STRATEGIC PARTNER -

*Ari Happonen *), Erno Salmela **)*
Lappeenranta University of Technology
*) DEPARTMENT OF INFORMATION TECHNOLOGY
**) DEPARTMENT OF INDUSTRIAL MANAGEMENT

ABSTRACT
This case based research examined Logistics Service Provider (LSP) client cases in which LSP provided different supply chain management support services, either for a one company or a network of companies. Case companies are mainly from manufacturing industries business area. The purpose of the paper is to reveal and report case data about the different possible roles of the LSP to make decisions and to support decision making in these client / client network situations. Paper also reveals case findings of role model development of a LSP's in machinery industries supply chains. In this paper it is described how in this industry context it seems LSP has to go through certain service model steps to archive higher level role in the client network, even in the case of good references from other clients and industry context. The paper intends to provide new information on research cap revealed and suggested to need more detailed reporting on the literature review done by (Selviaridis and Spring, 2007) about 4PL (Fourth Party Logistics) service provider managing business network. In this paper the role of the LSP includes the 4PL role as the operator can work as strategic decision maker, but also it has been shown how LSP could be a partner in tactical and operational level in Finnish machinery industry networks. Also additional information is show how it is seen in general, in the Finland, what is needed for the LSP to be able to get in to this role.

LITERATURE REVIEW:
According to Beech (1998), a supply chain oriented management philosophy aims to integrate the supply chain into as cost-efficient one as possible. In such cases, the customer's needs are at risk of being ignored. Therefore, the management philosophy of the supply chain should be linked to demand chain, and both philosophies should be examined together. According to Hoover et al. (2001), the aim of demand and supply chain management is to produce added value to customers, all the while improving the performance of the chain e.g. by reducing costs. Beech (1998) maintains that one needs to understand the demand chain in order to manage demand, meet customer needs and create all new demand.

Lund and Norrman (2009) state that strategic level decisions, made on the supply chain, typically generate changes to e.g. supply chain processes and construction. Decisions made in this level cannot happen without high level of experience and information. By (Niemi et al. 2004) decisions in strategic level requires information and knowledge from multiple sources, to be able to construct the big picture of the current situation. Arun and Desmukh (2008) mention that cooperative decision making support the process of solving conflicts between supply chain partners. In operative and tactical level Simchi-Levin et al. (1999) describe that typical tactical level decisions are that consider e.g. forecasts and inventories, decisions in operative level are e.g. routing of vehicles and freezing of the manufacturing plan.

Considering the customers need and the challenge of the operator and the information flows between supplier and operator and the operator and the customer the visibility in the chain is crucial from the performance point of view. The lack of demand visibility has been identified as an important challenge for supply chain management (Lee, 2002) which is the same problem which has been found out to generate problems on the case companies. Commonly, the orders placed by customers are the only factual demand information client companies (and also in these cases the logistics operator) has access to (Cachon and Fisher, 2000). However, order information often gives a delayed and distorted picture of demand, which affects the supply chain; 1) No "additional" time for planning and efficient reaction to demand, 2) Hard to combine orders to make the production more efficient (batch sizes and shipment planning).

CHALLENGE OF THE OPERATOR:

We have researched the current state of supply chain management processes in Finnish machinery industry. We found that essential future trends seem to be a development of material and information management methods (as a pair) through the supply chain, an outsourcing of supply chain management and purchasing related operations, and new roles of logistics operators as 3rd party players in supply chain. As part of the company network build up, the need for more advanced coordination effort increases. By (Sabastian et al., 2010) one possibility in these cases is the LSP as coordinators in these networks. These coordinators have to have the tools and skills so that they are able to work in different level of the value chains in these demand-supply chains.

In the Finnish machinery industry supply chains, development of the operational models will be needed for demand and supply management in supply chains to maintain competitiveness of the chains. Also the operators have to be able to offer new, more full fetches service models and at the same time enhance the efficiency of the current services to keep up with the change in the industry as main contractors and core companies in company networks are outsourcing more and more of their non core business sub sections. At the moment, internal processes of companies are performed quite well, but there is much to do to combine those internal processes together in new, more efficient ways. Also new operational models are needed to support better inter-company co-operation and information exchange practices.

For example, the manufacturer (client of the LSP) makes forecast of the near future demand, the LSP makes the decision what to buy, when, and what to keep in inventory and how much. In this case the role of the operator in this supply chain is already in tactical level as the decisions made by the LSP have direct impact to the clients ability to respond (in time) to the marked demand. Good decisions made by the LSP can enhance the agility and responsiveness of the client and of the supply chain, but on another hand, bad decisions have inverse result.

THE RESEARCH WORK

The aim of the study was to research and report the change of the LSP role in the studied SME sized machinery industries operator and client cases in Finland. The research was conducted as a multi-case qualitative study of one case company serving multiple clients. The qualitative research data was collected through interviewing of logistics operators company owners, logistics managers and logistics consultants reviewing the given cases from different service levels. The data for the research has been collected in spring and summer time in 2010.

From the generalization point of view the study is limited as the study concentrated only on Finnish case examples. As result, it is not easy to show, through the case study, is the found need to go through all the development steps present general all around the world. Also we cannot show, through this research, is this limitation tight only to small and medium sized companies or does it affect large sized LSP companies too. Based on the interviews of logistic service provider clients, it does look like that the found development steps are quite like general for most logistics service providers as the key components behind the need for going through the steps are the main reason not the size of the LSP.

RESULT AND FINDINGS

The study revealed general service role development model of the LSP in route from resource provider to the strategic network partner of a manufacturing industries companies and/or network(s). As a key element, why LSP has to go through the steps was a process of building the needed trust to give the operator the power of making the decisions in behalf of the client and to make recommendations to enhance the current business models in clients own supply chains. When the needed trust level is achieved the client is ready to allow the LSP to proceed to take new role in the supply chain and as such advance in new level in the operational, tactical and finally in strategic level of decisions and actions in the supply chains. As (Arun and Deshmukh, 2008) stated cooperative decision making supports the process of solving conflicts between supply chain partners. As the LSP is able to support their clients in this process, it results better relationships between the client and e.g. their suppliers, in the process the LSP is able to build up the trust of their clients towards the LSP.

As a result, of the study, a clear step-by-step model was found out which seems to be the usual advancing model in these client relationship cases of the Finnish SME-sized (Small and Medium Sized Enterprises) LSP. In this case study the LSP could have the possibility to be a strategic services provider e.g. making strategic decisions in the network for example by funding component inventories and by deciding which components to keep and how much in the inventory. Also the operator might have sourcing responsibilities and connections to third party engineering agencies/offices.

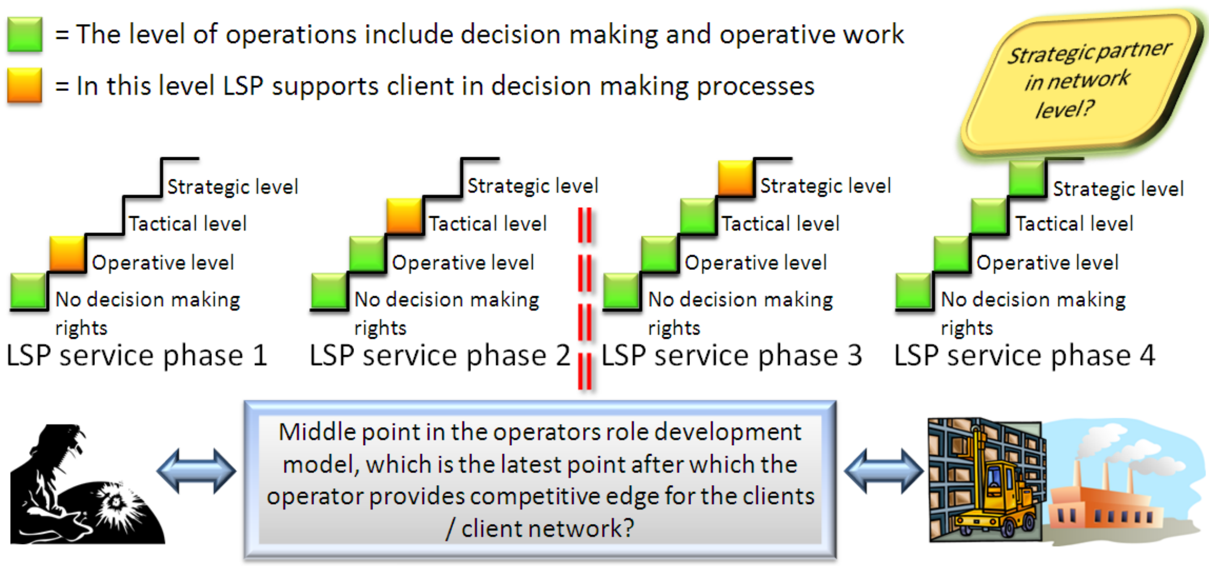
Basically it was found out that there is not any clear reason why operator could not be an strategic partner in all the client cases they have clients currently, but it seems to they have to be able first to show their "worthiness" client-by-client even in case of extremely good references from well known and still running client cases (e.g. from big name companies with good reputation and large influence and authority in their own industry sector).

In the time the research data was collected the case company LSP did see that their future role would be as a higher level strategic service provider, but they also see that to be able to be in that level they would still have to go through the generic operators' role step model in almost every client case. This was interesting as many of their customers have been visiting the operators other clients facilities, they have seen the results and working models this operator is offering for these other customers, and they have also heart the positive feedback from the other customers. Operator also reported that for every case they make and financial calculation that they show for their customers about the saving potentials when they suggest of advancing in new level in the business relations. But still after all this work and good references, the basic end result seems to be, that major, if not all, their customers need time to "grow internally" in their own companies to be able to accept the new role of the operator in their supply chains. It seems that it is not all about good results, reputation, and the references at all. Part of the puzzle is the trust of the customer towards the LSP, good results from the operational level work and "free work" of the LSP as supporter in the supply-chain decisions the client makes and ask the operators opinion and rationalizations for the opinion what to do and why.

This has been seen as notable research findings, as it would have been expected that because of the good client references the LSP would have been able to show the benefits for their new customers already in the start phase of the client – service provider relationship that would allow them to start from the higher steps of the model. It seems that in this business environment all client relationships have to be build from ground up, even in case of good references from earlier client cases. The explaining reason for this seems to be that the clients see that they had to change their own business model too much in too short time period, in one large step, which correlates to large risk factor. Because of the risk factor the gained trust from good references does not have weight enough against the risk of the change. Also it might be that some of the clients might still see logistics as part of their core operations, and as such are not so interested to outsource this business area, even if the operator is able to clearly show saving potentials for the client.

As a result of the study, through studying the generic step model found in the research (show in the Picture 1), a client of a LSP could be shown what to expect in near future in their LSP relationship, which might ease up some of the possible conflicts associated to the changes in the relationship and also build up the trust between the LSP and client as the future of the relationship and it's possibilities are known in beforehand. By using the model in conjunction with the references they have from earlier cases the operator now has a framework which they can lean on as part of their tool bag when communicating with the customers about the change of the relation ship in near future. So by explaining the step model it is possible to predict and explain possible changes for the customers in the near future and by so doing prepare them internally to the change. By giving the customer the possible clips of the near future they have more time to prepare the company internally which should result more positive attitude towards the change and it's possibilities.

When the LSP ads their client advance through the model, it was found out that, approximately in the middle point of the model, the operators role change from resource provider to an enabler of growth and a demand and supply chain synchronizer. E.g. for SME sized manufacturers LSP could be strategic partner when LSP owns the inbound stocks of the client, which the client would not have afford to own by themselves. As such the client will be able to respond more efficiently to the real demand and demand changes. This finding seems to be in line with (Lund and Norrman, 2009) as they stated that decisions made in strategic level are generally the ones that generate changes to the structure of the supply chain. As such, the operator has to be at least in the middle point of the model to be able to support the client in this decision making level.



Picture 1: Step model for the LSP in advancing in their client-customer relationship

As an example, in the following table (Table 1) it has been shown up what could be the operators role in different level and what sort of decisions the operator is doing and what are the decisions the operator is supporting their customers at.

Level in the model	Decisions made by the LSP	Decision support by LSP
Step 1: Decisions: No decision making rights Decision support: Operative level	- LSP does not have the rights do make decisions behalf of the customer	- LSP offer support to delivery vehicle routing decisions and supports in production plan freezing decisions based on inventory data.
Step 2: Decisions: Operative level Decision support: Tactical level	- Makes the decision what to order and when, based on the manufacturers frozen production plan. Also selects drivers for the day for given vehicles. - LSP re-routes vehicles to optimize the supply chain. - Buys material based on the clients purchasing agreements. - LSP controls the inbound inventory and makes the decisions what to order, when and how much.	- Supports client in making demand and supply forecast based on the inventory data. - Makes suggestions for inventory parameter changes based on the forecast. - Support the client´s decision what to purchase. - Supports client in production time table changes based on the ability of the supply network to respond to the changes in the demand.
Step 3: Decisions: Tactical level Decision support: Strategic level	- LSP generates forecast based on inventory data and demand data for the customer. Also optimizes the amount of items ordered in one batch. - Defines the time buffers for the orders based on the history date about delivery reliability of the supplier. - Designs the packets and selects the materials for the packets of the final products.	- Supports client in decisions changing the supplier based on suppliers performance. - Supports their customer in decisions to what machinery to invest and when in the future. - Supports the client in selecting of future IT-systems and sourcing management method and tool selection.
Step 4: Decisions: Strategic level Decision support: Network level	- Has the authority to change the suppliers and to acquire new ones, e.g. LSP can define sourcing strategies, material supplies and partner in inbound and outbound logistics. - Defines the IT-systems used for logistics. Also selects the service provider for the systems. - Decides the physical location of the warehouse.	- LSP supports whole supply chain network in network level optimization decisions (e.g. who to take and who not to take in the core network and also where to keep inventories in the network to support network level strategies). - Supports the network in network level supplier decisions
Step 5: Strategic partner in network level	- Has authority to make decisions that affect the whole supply chain over the whole supply network. For example defining all warehousing and inventory points in the whole supply chain.	- LSP has the authority to make decisions that affect the whole supply chain over the whole supply network.

Table 1: Different decisions and operator roles in the model

When the step by step model was developed and tested in the operator case for it's validity, (e.g. operator had to classify how many cases they had in which level of the model, and also it was discussed are the selected model good reflection of the real-world operations), it was found out that the model did indeed depict the reality of the LSP’s business area quite well. In this particular case study, the LSP classified their customers as follows:

- Step 1: 40 %
- Step 2: 45 %
- Step 3: 10 %
- Step 4: 5 %

Currently the operations of the LSP aren’t generally optimized based on multi source information from client network; mostly the optimizations are done in case by case basis. The operator has started to build up models for client network level optimizations, which will include collection of information from multiple client networks simultaneously to be able to not just to optimize one network at the time but also to be able to optimize operations in multiple client networks side by side.

From future research point of view, it would be really interesting to research the role of the operator in business network, in which the operator would work in the third or fourth level in the step model and as such would be able to make decisions that would result changes in the whole supply chain from start to finish. In this context it would be possible to research the optimization capabilities and synchronization possibilities which a highly skilled third party can offer for a wide business network. Currently, at least in Finland, it seems that optimization in network level is still not typical and most of the optimisation happens in dyad level. In this research only few cases was found out, in which the operator had the possibility to affect supply chains in network level.

DISCUSSION

The LSP role changing step model found in the study, could give the LSP and their client companies, a new perspective for the future relationship. What are the roles the operator might work with the client and what are the steps needed to get in the target role. On another hand, through applying e.g. LSP based funding services in the start of the client relationship, it might be possible to go faster trough the steps of the model to get to the final goal level faster.

When the operator is trying to get past the first to step to the level in which the LSP will make tactical level decisions, it was said, by the case companies, that the LSP has to had been able to show that they are able to provide decision making support to the supply and demand synchronization before they should be able to get this position. For example, the operator is able to suggest new stock control policies with a change in to the production control mechanism to synchronize the production to the supply chain and vice versa. This is in line with the Hoover et al. (2001) definition of what is the basic goal of the demand and supply chain management in the first place. When the operator was asked for what they do to show their clients that they are able to support their customers in the tactical level, operator responded that they offer their own models and tools for their clients to e.g. add to the demand visibility and by so doing they ease up the tactical level decisions (e.g. production control, inventory control, management methods, machine usage and future choices, human resource allocation and information and knowledge management) and offer support for making the correct decisions. As a tool of responding to this challenge it seems the LSP has selected the right one as it is also supported by the (Lee, 2002) who stated that the lack of demand visibility has been identified as an important challenge for supply chain management in general. Also as (Sabastian et al., 2010) stated it is possible that a LSP can work as the network level coordinator (with right tools & skills) it seems that our research results support this statement as the case findings suggest exactly the same level of experience needed from the LSP for them to be able to proceed in their customer relationship in the new levels.

Even as it seems that manufacturing customer companies are interested in increasing the outsourcing of logistics and supply chain management activities and decision making for the LSPs, it also seems that the manufacturing companies might be little vary in trusting the LSP's ability to have all the necessary skills and/or tools to be able to provide demanding supply chain management services they claim they are able to. The LSP has identified this lack of trust and they are stating time after time that they hope there would be more competition in this sector in the future to show their clients that these services are really available in multiple sources and they are advancing all the time because of the high level of competition.

It should be noted that the boundary between the LSP role models is not sharp and clear black & white model. Roles can overlap in practice, especially when the operator starts to support their client more and more in daily decisions, but when there isn't still clear contract for the relationship what decisions are exactly who's responsibility. For example (Selviaridis and Spring, 2007) write:
"*In the context of logistics services more specifically, procurement frameworks (e.g. see Andersson and Norrman, 2002) present a linear, step-by-step process and fail to reflect the dynamics of service definition/design which also relate to economic and contractual aspects e.g. price and service volume variations (Halldorson and Skjott-Larsen, 2006).*"

When we compare this to our model, and the mentioned "grey area" between model steps as part of the change of the role of the operator in their client cases, to us it seems that even when this model seems to have strict linear structure, it still allows the flexibility when defining the LSP role through the model as it allows operator to make the support work in the higher level of the model, even in case of the major part of the work is done in the lower levels.

CONCLUSIONS

This research has focused on a study of the role of LSP in the Finnish machinery industry supply chains between the manufacturer and the subcontractor. In this study a model of the LSPs role in these cases was found. Based on the results a trust between the LSP and the customers is the key issue why it is needed by the LSP to go through all the steps when advancing in their role in their client cases. It was also found out that the operator is able to advance faster in the model, if it is able to keep everything open in their business model towards their customers. With open books business model and fair (e.g. event based) pricing structure, the LSP is able to build up the trust between the client and LSP quite rapidly.

It was also find out that in general LSP offers "free" consultative support for their clients one step further in the model compared to the current decision making role on the model. This double role of the LSP in the model seems to works as a building block for deeper trust between the companies in the future, which was found out to be the key factor for advancing in the next level in the model. So, basically operational level work, with decision level support work in tactical level, is the building block for the LSP to be able to get in the position to be able to make the tactical level decisions in the future. Good results in tactical level decisions and support in strategic level decisions is the building block for making the strategic level decisions in the future and so on. In these studied cases it seems that good references will not allow the operator to step over this development model, but good references might make the journey faster and easier.

The limitation of this study was the small number of the cases researched that limits the generalization of the study. The second possible limitation concerns on the fact that the study was performed only in the Finnish environment regarding machinery industry. In follow-up studies, the LSP role model should be tested in different industries and with larger number of LSPs.

REFERENCES:

Andersson, D. and Norrman, A. (2002), Procurement of logistics services: A minute's work or a multi-year project? European Journal of Purchasing and Supply Management, Vol 8, pp. 3-14.

Arun Kanda, A, and Deshmukh, S.G. 2008, Supply chain coordination: Perspectives, empirical studies and research directions, International Journal of Production Economics, Vol. 115 No. 2, pp. 316-335.

Beech, J. (1998), The supply-demand nexus. From integration to synchronization, Strategic Supply Chain Management. Best practice in supply chain management, Gower Publishing Limited, pp. 92-103.

Cachon, G. and Fisher, M. (2000), Supply chain inventory management and the value of shared information, Management Science, Vol. 46, No. 8, p. 1032 - 1048

Halldorsson, A. and Skjoett-Larsen, T. (2006), Dynamics of relationship governance in TPL arrangements - a dyadic perspective, International Journal of Physical Distribution and Logistics Management, Vol 36 No 7, pp. 490-506.

Hoover, W.E., Eloranta, E., Holmström, J. and Huttunen, K. (2001), Managing the Demand-Supply Chain. New York, John Wiley & Sons, Inc.

Lee, H.L. (2002), Unleashing the power of intelligence, ECR Journal, Vol. 2 No. 1, pp. 61-73

Lundin, J. and Norrman, A. 2009, The Misalignment cycle: Is the management of your supply chain aligned? Proceedings of The 21st Annual Nofoma Conference, 11-12 June 2009, Jönköping, Sweden, pp. 547-565.

Niemi, P., Pekkanen, P. and Huiskonen, J. 2004, Understanding the strategic supply chain decision making – when solving a model is not enough, Euroma 2004 proceedings, pp. 435-444

Sabatier, V., Mangematin, V.and Rousselle, T. (2010), Orchestrating networks in the biopharmaceutical industry: small hub firms can do it, Production Planning & Control, Vol. 21, No. 2, pp. 218–228

Selviaridis, K. & Spring, M. (2007), "Understanding the dynamics of service exchange design in industrial markets: The case of third party logistics", in 23rd IMP Conference, 30 August-1 September 2007, Manchester Business School, Manchester, U.K.

Selviaridis K and Spring M (2007), "Third party logistics: a literature review and research agenda", The International Journal of Logistics Management, Vol 18, Issue 1, pp. 125-150

Simchi-Levi, D., Kaminsky, P. and Simchi-Levi, E. 1999, Designing and Managing the Supply Chain, McGraw-Hill, London

INNOVATION IN LOGISTICS SERVICES – *HALAL* LOGISTICS

Harlina Suzana Jaafar[1], Intan Rohani Endut[2], Nasruddin Faisol[3], Emi Normalina Omar[4]

[1, 2, 3, 4]Malaysia Institute of Transport, Universiti Teknologi MARA, MALAYSIA
[1, 4]Faculty of Business and Management, Universiti Teknologi MARA
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, MALAYSIA
[3]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, MALAYSIA

INTRODUCTION

The expansion of liberalisation in trade and services has forced companies to consider the global market demand in their competitive strategic planning. Hence, firms need to be continuously responsive to the market demand in order to stay competitive. Various research have shown that innovation can be the source of additional revenues to companies, help to save costs (Calantone, 2002; Dilk et al, 2008; Grawe et al, 2009; Kandampully, 2002) or improve the quality of existing process (Khazanchi et al, 2007) as well as driving potential for competitive advantage (McGrath and Ming Hone, 1996). In fact, the benefits of innovation have been discussed as early as 1911 by Schumpeter. Flint et al (2005) highlight that innovation is particularly vital to logistics service providers as it helps to gain competitive advantage. However, the concept of innovation has been largely ignored in logistics research. They stress that many research on innovation focuses on general product innovation and more specifically on highly technological innovation. With exception to a few studies (e.g. Fuglsang, 2002; Gustafsson et al, 2002; Mattson, 2002; Zacharia, 2001), several authors have also demonstrated the lack of studies on service innovation (Flint et al, 2005). A review analysis study conducted by Busse and Wallenburg (2011) demonstrate the non-existence of a well-established research stream on LSPs' innovation management. Previous studies have been concentrating on the demand of industry specific solutions (Langley et al, 2005), which emphasise on the individual customers' importance. It provides opportunities for LSPs to address individual customer wishes within innovation projects, as well as to generate innovations in close coordination with their customers (Flint et al, 2005; 2008).

Recently, the concept of *halal* has obtained increasing attention as a result of the rising number of Muslim population globally. The consumption and promotion of the *halal* food is becoming significant as it associates with quality, cleanliness and safety as underlines by the *syariah* principles. *Syariah* is the divine law of Islam, derived from the Qur'an and other holy text, which serves as a moral guide to Muslims. The *syariah* sets guidelines for what is right and wrong in everyday life, including standards for food, family life, and business transaction. The fact that the non-Muslims can consume *halal* food enhance the importance of producing more *halal* products as the consumer market is widened when the product could be consumed by all consumers. However, previous studies on *halal* have largely been conducted in the area of food science and agriculture, in which the concentration was given on *halal* food manufacturing. Other research on *halal* supply chain is focusing on traceability, which applies the technological tools for traceability. However, to date, studies that are focusing on *halal* from the perspective of logistics management have been largely neglected. Accordingly, this study highlights the logistics service innovation that have been introduced and implemented by two leading logistics companies in Malaysia. It also demonstrates its implementation and the impetus of its implementation. It portrays the requirements and procedures involved to produce the *halal* logistics service.

BACKGROUND OF THE STUDY

Innovations and Logistics

Innovation is defined by Schumpeter as the implementation of new combinations of product, process and organisational innovations that would provide new access to markets of suppliers or consumers (Schumpeter, 1994). It also involves deliberate application of information, imagination and initiative in exploiting greater or different value from resources, and encompasses all processes by which new ideas are generated and converted into useful products. To be called an innovation, an idea must be replicable at an economical cost and satisfy a specific need. In line with Schumpeter (1934), Flint et al (2005) emphasise that innovation is not limited to only technological breakthroughs or products alone, but the concept of innovation could occur within services, processes, or any social system. The impact of innovativeness on firm performance and economic growth has been of interest to economists for decades (e.g. Mansfield et al, 1971). Innovativeness has been consistently and significantly become significant determinant to higher firm performance (Deshpande and Farley, 2004; Calantone et al, 2002; Li and Calantone, 1998; Mone et al 1998;) as it enables firms to offer greater variety of valuable, rare, inimitable and differentiated products (Barney, 1991).

Flint et al (2005) define logistics innovation as any logistics-related service that is seen as new and helpful to a particular customer. The innovation may include internal and external operation that could improve operational efficiency and innovations that could serve a customer demand. In supply chain management, firm innovativeness is promoted and measured in terms of frequency of introducing new internal logistics-related processes and the ability to seek out new creative ideas in methods of operation. Panayides and Lun (2009) highlight that even orienting a firm's culture towards innovation is likely to enhance supply chain performance. Supply chain innovations could also be in the form of combined developments of information and related technologies with new logistics and marketing procedures to improve operational efficiency and enhance service effectiveness (Bell et al, 2004). Bowersox et al (2002) underline managers often focus on major cost savings and service improvements that accrue to domestic trading partners adopting supply chain innovation. Accordingly, supply chain has always been viewed as the most important areas to be innovated as it offers an effective means to gain efficiencies and eliminate accumulating competitive pressures. However, extant studies have focused only on a particular aspect of innovation, such as technological innovation (Busse and Wallenburg, 2011; Shen et al, 2009; Lin, 2008) reflecting the lack of studies in service innovations.

Understanding *Halal*

Halal is an Arabic word which means lawful or permissible. The term *halal* is used by the religion of Islam to guide Muslims in everyday life. Muslims believe that Allah (The God) is the Creator and Muhammad (The Prophet) is the final Messenger of Allah. *Halal* refers to all that is permitted and *Haram* refers to all that is prohibited according to the guidelines given by Allah in the Qur'an and explained (Sunnah) by the Messenger of Allah (PBUH). The Islamic dietary laws are derived primarily from the Qur'an and the Sunnah of the Messenger of Allah (PBUH). The basic principle is that all foods are *halal* except those prohibited in the Qur'an and the Sunnah. This reflects that no one has an authority to declare *halal* and *haram* except Allah. The foods that are not permissible are namely swine or pork and its by-products, carrion or improperly slaughtered halal animals, animals killed in the name of anyone other than Allah, carnivorous animals with fangs such as lions, dogs, wolves and tigers, birds of prey such as falcons, eagles or owls, snakes, domesticated donkeys, mules and elephants, pests such as rats and scorpions, insects excluding locusts, blood and blood by-products, alcohol and intoxicants of all kinds, all poisonous plants and poisonous aquatic (unless the poison is removed before consumption), and food which is contaminated with any of the products mentioned above (Lodhi, 2010). In Islam, each of these foods has its own argument of why it is forbidden to the Muslims as Islamic dietary laws strictly adhere to quality, cleanliness and safety of the food that they consume. Generally, the specific reasons of *Haram* in Islam are to (1) preserve the purity of the religion (2) safeguard the Islamic mentality (3) preserve life (4) safeguard property (5) safeguard future generations (6) maintain self-respect and integrity (Ahmad, 2008).

Factors Driving the Significance of the *Halal* Industry
The rising number of Muslim population around the globe has indirectly driven an impact to a tremendous demand for *halal* products recently. The world's Muslim population is expected to increase by about 35 percent in the next 20 years, rising from 1.6 billion in 2010 to 2.2 billion by 2030. Globally, the Muslim population is forecast to grow at a rate of 1.5 percent annually. If the current trend continues, Muslims will make up 26.4 percent of the world's total projected population (The Pew Forum, 2011). Lodhi (2010) claims that the increasing purchasing power among the Muslims around the world also contributes to the increase demand for *halal* products. Customers are willing to pay at higher price as it associates with the belief in Islam that the Muslim should consume clean, safe and quality products. Several researchers emphasise that presently, customers are more educated and thus, becoming more demanding as they are meticulous of the status of the food they consume (Mohammed et al, 2007; Yaakob et al, 2007).

On the basis of costs savings, the implementation of market liberalisation recently has led to the globalisation of food trade that has called more international business operations. However, to run a successful international business operation requires sufficient market demand (Lodhi, 2010). Accordingly, the production of *halal* food may be sufficient to fulfil the market demand as the food market is wider when non-Muslims could also consume *halal* food, thus enhances the need to produce more *halal* products.

As a result, the increasing demand for *halal* products has led to many studies focusing on its manufacturing processes. However, as the *halal* food trade is more globalised, its supply chain is getting more complex. Thus, consumers are now concern not only the manufacturing process, but also all activities along the supply chain of the *halal* food products. This is because the *halal* compliance applies to the entire supply chain ranging from the sourcing of raw materials to the manufacturing, transportation, warehousing, freights handling. Accordingly, the *halal* status of a product could be affected when they are in direct contact with the non-*halal* products; unless it is completely segregated. As such, to maintain the *halal* status of the products requires a different procedure of handling, storage and managing the product. Thus, the purpose of this study is to present two case studies that demonstrate innovations created in the logistics service, i.e. *halal* logistics services, as to fulfil the increasing demand of the customers throughout the world particularly the rising number of Muslim population.

RESEARCH METHODOLOGY
This study uses case study approach to elaborate the implementation of *halal* logistics practice. Busse and Wallenburg (2011) underline that exploratory approach may be particularly appropriate for LSP's innovation management research since it is at a very early stage and that the future research should place more emphasis on how innovation emerges. In achieving the objective, the literature on innovation, logistics innovation, *halal* concept and halal industry were reviewed. The importance of both concepts of innovation and *halal* were elaborated to provide better understandings on the concepts. The rationale on how *halal* logistics services could be considered as innovation and how the concept could be applied to logistics services would also be highlighted. Two leading logistics service providers in Malaysia have been chosen to be the cases. Each of them was labelled as Company ABC and Company XYZ in this paper. The data is gained from seven interviews conducted separately at both premises comprising of corporate and operation managers from both Company ABC and Company XYZ (refer to Table 1).

Position	***Company***	***Length of Experience in the industry***
General Manager	Company XYZ	15 years
Manager (Halal Focal Person)	Company XYZ	10 years
Head of Halal Business Unit	Company ABC	11 years
Head of Logistics Infrastructure	Company ABC	12 years
Head of Warehouse	Company ABC	6 years
Branch Manager	Company ABC	9 years
Head of Corporate Communications	Company ABC	9 years

Table 1: The Background of Informants

The length of experience indicates the reliability of the information obtained. The detail elaboration of both case studies is as follows:

CASE 1: COMPANY ABC

Background of Company

Company ABC started its first haulage operations in December 1971 and is recognised as the pioneer haulage company in Malaysia. It started its operations with only single prime mover and three trailers. Over the years, ABC has expanded and ventured into port operations, international freight forwarding, warehousing, shipping, contract logistics and supply chain solutions. Currently, ABC has earned its reputation as the leading one stop logistics company providing comprehensive logistics solutions with multiple ranges of services. Operating at all key entry points into the country, ABC has expanded its operations worldwide with representation in 34 countries, creating a truly global relationship. Having been in the market for 40 , ABC has a wide range of clients. ABC always focus in delivering the best services to their clients by delivering their logistics expertise, with state of the art technology, outstanding people and established processes certified by the International Organisation for Standardisation (ISO).

ABC's Halal Logistics Service Innovation

As the *halal* industry is becoming significant, ABC feels obliged to response to the need of implementing a *syariah* compliance supply chain of *halal* goods. This becomes strong impetus to be innovative in terms of being the market leader and pioneer in the *halal* market. As a result, ABC began working for *halal* certification application. Having several ISO certifications for their warehouses, the application to be a *halal* logistics service provider became easier. These certifications have recognised their service operations as hygiene and clean. The best strategic move taken by ABC during the application process was to work closely with the Department of the Islamic Development of Malaysia (JAKIM) in acquiring consultation and sharing views on the related processes based on *halal* requirement. The process involves remarkable discussion time, countless of visits, corrective actions as well as views exchange. After six months of hard effort in preparing the warehouses and fleets fully recognised, finally ABC became a *halal* compliant premise under the *halal* certification of JAKIM for *halal* logistics provider. Presently, ABC provides full end-to-end of *halal* logistics services including (1) consultation of *halal* applications to relevant authorities for consumer food and product manufacturers (2) h*alal* freight consolidation (3) cross-border and multi-mode international *halal* freight forwarding, (4) destination *Halal* hub/port and customs (5) *halal* warehousing (6) *halal* distribution, returns and recalls.

As the demand for a *syariah* compliance handling and storage of *halal* food is increasing, ABC needs to be innovative in offering an exceptional value of logistics service to the customers, in which they introduce *samak* service on containers. *Samak* is an Islamic term referring to ritual cleansing. Purification or *toharah* plays a very important role in Islam. A Muslim's *ibadah* (worship) prayer may be rejected if *toharah* is being neglected.

Therefore all Muslims have to follow the correct procedures in cleaning and cleansing all kinds of dirt according to *syara'* especially when dealing with *mughallazah* filth (heavy impurities) obtained from dogs and pigs. As stated earlier in this paper swine or pork and its by-products as well as dogs are considered as *mughallazah* filth. In Islam, the only way to clean *mughallazah* filth is by washing the affected area seven times. The first washing should be conducted with water mixed with earth (soil or sand), and the other six with clean running water to ensure *toharah* or purification is taken place. If an object was once contacted with *haram*, *samak* will have to be performed on the object.

Samak Service in ABC

Samak service is performed on containers based on customer request. Customers would normally request for this service when they feel that the *halal* status of the product would be affected due to possible contamination that may occur when the product is carried by the container. The service begins with the request for *samak* from the customer. The container will be graded as "A" indicating it as container for food product, which should be cleaned as according to Grade "A" cleanliness standard. Then, the container will be parked at the *samak* centre. For the first five minutes, the personnel in charge will perform a second inspection to ensure all visible dirt is removed from the container. Then, the personnel starts the *samak* service by firstly washing the container with earth (soil or sand) mixed water. The other six times of washing is conducted with clean running water. By using a water jet, the water is sprayed in a circular movement from one end to the other end of the container to ensure that all parts of the container are clean. The container is then dried out and sealed with the *samak* sticker. The whole process takes approximately 15-20 minutes. One of the requirements in performing the service is to ensure that the compound is clean and free from any possible contamination with the non-*halal* items including the food consumed by the personnel, who is on duty. This stringent process is to ensure a complete cleanliness, quality and safety of the handling and storage of food products. Having conducted a comprehensive cleaning process, the customers only required to pay only a minimal handling fee. Hence, the value that is offered to the customers is ensuring the *halal* status of the product they carry.

CASE 2: COMPANY XYZ

Background of Company

XYZ is among the pioneer companies to provide *halal* logistics services. Formed in 2001, XYZ is a well-recognised one-stop logistics service provider, which integrates almost all forms of logistics services available that includes ocean freighting, distribution, freight forwarding, warehousing and as such providing customers personalised solutions in order to meet local, regional and global requirements. XYZ operates a strategic network of warehouses and distribution centres in major locations within the region. The organisation's supply chain solutions are supported by its sophisticated information technology (IT) systems to efficiently control and manage its entire supply chain. The complete range of IT solutions covers warehouse management system, haulage, freight, fleet, container, global positioning system (GPS) and sea liners, leveraging on parent company's global network, architecture and security framework. In 2007, XYZ launched its XYZ Logistics Hub (MLH), a new generation 90,000 square meter multi-modular storage facility offering inventory management, warehousing, haulage and distribution services, freight and customs management, container yard and cold storage facilities, supported by an integrated IT platform with global connection and outreach. MLH has been awarded free commercial zone status, leading to cost savings to its customers.

An Innovative Solution to Halal Logistics

Taking into consideration all factors of growth in the *halal* industry, XYZ realises that it has a strong potential to be at a frontrunner. With that, XYZ introduced its innovative *halal* logistics solution. *Halal* logistics applies to the application of *halal* practices in the entire supply chain from raw materials, to manufacturing, transportation, warehousing, ports, freight handling and right up to consumer consumption. *Halal* integrity, which involves religious beliefs, cannot be compromised at any stage and consumers are highly demanding in terms of quality and assurance when it comes to *halal* products. As such, the main challenge for XYZ is the assurance of the highest level of *halal* integrity throughout the supply chain. XYZ addresses this challenge through its innovation in *halal* logistics, where XYZ has created an integrated *halal* supply chain, which manages the material flow throughout the supply chain in compliance to *halal* standards. The key principle that they practice is the segregation of *halal* and non-*halal* products in every process that the product goes through, i.e. transportation, storage or warehousing and handling. In ***transportation***, XYZ's inbound and outbound transportation to/from the warehouse are secured as there is a mutual understanding between XYZ and its customers on preserving the *halal* integrity of the transportation process. Transportation is handled by a panel or transporters appointed by customers who are the major food brands in Malaysia and highly concerned with *halal* assurance.

To ensure *halal* compliance in ***storage and warehousing***, XYZ dedicates MLH to the handling of only *halal* products and ensures that it receives each product's *halal* certificates prior to the arrival of physical products at MLH's cold warehouse. Once the *halal* product is received at the required temperature, XYZ staff performs the routine check on the product to ensure MLH *halal* integrity is preserved: (1) the *halal* logo at the packaging is recognised by JAKIM, (2) the presence of non-*halal* products/substances, (3) condition of packaging and container seal, (4) presence of foreign objects, and (5) similarity in shipment quantity between delivery order and actual received. The *halal* products will then be palletised, labelled and put away into relevant storage areas within a specified time period to ensure that the freshness is not compromised. For value added services, i.e. repackaging and labelling, XYZ manages them at designated area in the warehouse. For outbound distribution, the required cargo will be picked based on order, staged and loaded into the container or truck of the panel transporters to the destination. By dedicating a hub exclusively for *halal* goods, XYZ is able to ensure customers of the *halal* integrity of its supply chain.

To further improve the operations of *halal* supply chain, XYZ *halal* logistics is managed effectively by a dedicated team of management and operations personnel through the establishment of its ***Internal Halal Committee*** to monitor, identify, record and report any problems with regard to *halal* processes and ultimately ensure effectiveness in implementation of internal *halal* controls. XYZ's *halal* logistics operations are not only subject to audits by the by the internal team at specific intervals but also by relevant external authorities. The timely audits ensure that *halal* logistics is performed according to the requirements. To continuously ensure *halal* integrity in its service, XYZ has increased efforts and resources in facility maintenance and ***training*** for its employees. This initiative is to create awareness and knowledge amongst its employees in managing *halal* products as well as ensure its effectiveness in terms of application. As for the critical areas in *halal* logistics i.e. people-compliance, entry point tracking practices and damaged goods, need to be properly controlled. XYZ also invest in technology, which plays an important role in providing product traceability through the storage of data such as product designated code, batch manufacturing number, expiry date, etc.

DISCUSSION

Several aspects could be highlighted from the elaboration of the two case studies. As has been stated earlier, *halal* logistics services require a special procedure of managing the supply chain. **First**, a company/LSP should have a comprehensive understanding of the *halal* concept and its rationales before implementing it. It is because *halal* status is only gained when the concept is fully implemented, referring to the entire activities along the supply chain, namely sourcing, manufacturing, transportation, storage/warehousing and handling. The *halal* products need to be completely segregated from the non-*halal* products/substances and maintain the quality of the product throughout the whole process of along the chain in order to achieve the *halal* status of the product. Once the *halal* product is in direct contact with the non-*halal* products/subtances, the *halal* product would become non-*halal*. But if the non-*halal* product is in direct contact to the storage, equipment and handling facilities, a *samak* (ritual cleansing) could be performed. This provides ground for ABC to offer *samak* service. As the Head of *Halal* Business Unit of Company ABC stated that *"we or the customers wouldn't know what types of products that the container has carried because the container travels around the world. It could be anything that is non-halal. So this service provides assurance on the halal integrity of the product".* The ***segregation*** could be in the form of segregation by compartment, racking system or proper packaging, in which there is no possibility for the products to get contaminated from the non-*halal* products/substances. The segregation does not only apply to the possibilities of halal and non-*halal* products are mixing together, but the principle of segregation also applies to the employees handling the products as well as the equipment, machinery or any devices used to handle the products. Consequently, one should have a good understanding on the best way to perform the supply chain activities of the *halal* product so that the *halal* status could be achieved.

An alternative solution that could be easier is by practicing a fully ***dedicated*** logistics services for halal products. This has been demonstrated in Case study 2. The advantage emerges when the logistics providers do not have to comprehensively particular in the segregation process among the *halal* and non-*halal* products. Being a Muslim country, Malaysia has the credibility to offer these services as the majority Muslims bring along the demands for the *halal* products. As indicated by the General Manager of Company XYZ, "*we don't have that much problems handling and storage of the halal products as our warehouse is dedicated for halal products. And with the transportation, we only deal with our panel of transport providers and clients who are really committed in producing and delivering the halal products".*

Third, having understanding the role of the two principles of handling the *halal* products namely segregation and dedication; to implement a complete *halal* supply chain across sourcing, handling, storage and delivering is very challenging. This phenomenon could obviously occur especially in those countries that have high consumption of the non-*halal* products particularly food because the 'dedicated' practices could lead to higher cost of operation. **Fourth**, based on the case studies presented in this paper, it can be concluded that to achieve a *halal* supply chain compliance product is almost unattainable. This is because the halal supply chain service offered by the LSP is guaranteed only when the products are in their custody. But, once the products are transferred to the custody of the other party, the chances of breakage in chain is higher when the other party is not practicing *halal* supply chain. This situation is more critical at the retail level especially the small retailers due to the lack of control and monitoring by the responsible institution at their level. However, the operation practiced by company XYZ in Case Study 2, in which they only work with a panel of suppliers and customers, who are committed to *halal* supply chain practices would potentially resolve this issue. It could also be possible if a food company controls its complete supply chain, thus allowing the practice of *halal* supply chain. It is also important to note that the *samak* service offered by ABC is only a value-added service, which is available when the customers need it.

CONCLUSION

This study found logistics service innovations in the area of *halal* logistics, which have taken into consideration several factors such as comprehensive hygiene practices, quality and safety and thus, crucial to the non-Muslim customers. This study contributes to the advancement of knowledge through the application of *halal* concept into logistics service practices. The needs to be innovative in initiating more logistics services that are based on *halal* concept are crucial in meeting the needs of the increasing demand by the customers especially the Muslims. The findings provide insights to the practitioners of the importance to be innovative in creating more *halal* logistics services to fulfil the growing demand of the halal products.

SELECTED REFERENCES

Ahmad, K. (2008), “Management from an Islamic Perspective: Principles and Practice”, International Islamic University Malaysia, IIUM Press, Malaysia.

Busse, C. And Wallenburg, C.M., (2011), “Innovation management of logistics service providers: foundations, review and research agenda”, *International Journal of Physical Distribution and Logistics Management*, Vol.41, No.2, pp. 187-218.

Calantone, R. (2002), “Learning orientation, firm innovation capability, and firm performance”, *Industrial Marketing Management*, Vol. 31, pp 515-524.

Craighead, C.W., Hult, G.T., Ketchen Jr, D.J. (2009), “The Effects of Innovation-Cost Strategy, Knowledge and Action in the Supply Chain on Firm Performance”, *Journal of Operations Management*, pp. 405-421.

Dilk, C, Gleich, R., Wald, A. And Motwani, J., (2008), “State and development innovation networks: Evidence from the European Vehicle Sector”, *Management Decision*, Volume 46, pp. 691-701.

Flint, D.J., Larsson, E. And Gammelgeard, B. (2008), “Exploring processes for customer value insights, supply chain learning and innovation an international study,” *Journal of Business Logistics*, Vol.29 No.1, pp. 257-81.

Flint, D.J., Larson, E., Gammelgaard, B., Mentzer, J.T. (2005), “Logistics Innovation: A Customer Value-Oriented Social Process” *Journal of Business Logistics*, Vol.26 No.1, pp. 113-147.

Fuglsang, Lars (2002), “Systems of Innovation in Social Services”, in Jon Sundbo and Lars Fuglsang eds., *Innovation as Strategic Reflexivity*, pp.164-180.

Grawe, S.J., Chen, H. and Daugherty, P.J., (2009), “The relationship between strategic orientation, service innovation and firm performance”, *International Journal of Physical Distribution and Logistics Management*, Vol. 39, pp 232-300.

Gustafsson, A., Edvardsson, B. And Sanden, B., (2002), “Mapping Customer Behaviour: A Key to Successful New Service Development and Innovation”, in Jon Sundbo and Lars Fuglsang eds., *Innovation as Strategic Reflexivity*, pp. 140-163.

Kandampully, J. (2002), “Innovation as the core competency of a service organisation: the role of technology, knowledge and networks”, *European Journal of Innovation Management*, Vol. 5 , pp. 18-26.

Khazanchi, S., Lewis, M.W. and Boyer, K.K. (2007), “Innovation supportive culture: the impact of organisational values on process innovation”, *Journal of Operations Management,* Vol. 5 No. 4, pp. 871-84.

Lin, Y., Wang, Y., Yu, C., (2010), “Investigating the Drivers of the Innovation Channel Integration and Supply Chain Performance: A Strategy Oriented Perspective”, *International Journal of Production Economics*, Vol. 127, pp. 320-332.

McGrath, R.G. and Ming Hone, T., (1996), “Innovation, competitive advantage and rent: a model and test”, *Management Science*, Vol. 42, No. 3, pp. 389-403.

Schumpeter, J.A. (1934), *The Theory of Economic Development*, Harvard: Oxford University Press.

Shen, H., Wang, L., Xu, Q., Li, Y. And Liu, X., (2009), “Toward a Framework of Innovation management in Logistics Firms: A Systems Perspective”, *Systems Research and Behavioural Science*, Vol.26, pp. 297-309.

The Pew Forum on Religion & Public Life (2011), “The Future of the Global Muslim Population: Projections for 2010-2030”, accessed at *http://pewforum.org/The-Future-of-the-Global-Muslim-Population.aspx?print=true*, on 1st April 2011.

Zacharia, Z.G. and Mentzer, J.T., (2004), “Logistics Salience in a Changing Environment”, *Journal of Business Logistics*, Vol. 25, No.1, pp. 187-210.