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Configuring Next Generation Supply Chains

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INTERNATIONAL ADVISORY COMMITTEE

INTRODUCTION

We would like to welcome our friends and colleagues to the annual International Symposium on Logistics (15th ISL). It is 17 years since the first symposium on Logistics was held in Nottingham in 1993 and has now become a regular, well-established and 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). This year's event in Kuala Lumpur, Malaysia continues with the tradition following the very successful and productive event held in Bangkok last year. As usual ISL 2010 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 15th International Symposium in Logistics is *"Configuring Next Generation Supply Chains". Configuring the next-generation of supply chains supply chain requires attention to the dimensions such as designing the right logistics network, engaging in the right alliances and partnerships, developing contingency plans against uncertainties and selecting the right manufacturing processes, inventory levels and distribution strategies. This also means the need to develop network of all the entities in the extended supply chain, from product design and development to procurement and sourcing, supply and demand matching, logistics and distribution, sales force automation, and customer support. Within the extended supply chain, Information and Communication Technology (ICT) plays a central role by facilitating dynamic planning of flow of products, and assists in controlling and monitoring the execution of commercial transactions. The increasing level of international trade between countries often implies higher uncertainty and thus the need to identify underlying causes and strategies to protect against potential disruptions and risk. In order to address some of these issues it is important to capitalise on the know-how and expertise of academics as well as practitioners in the industry to share and exchange the emerging trends and developments. In our view the 15th ISL in Kuala Lumpur represents a timely opportunity for academics and researchers to address pertinent issues surrounding logistics and supply chains within a global context. Malaysia is a country that has a rich history, tradition and culture and is uniquely positioned to face the challenges that lie ahead over the next decade or so. We are optimistic that this year's event provides an opportunity to address some of these issues and challenges.*

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. As a result papers are included in this volume with contributing authors coming from countries. This book of proceedings has been organised according the following categories:

- *Supply Chain Management*
- *Supply Chain Inter-Firm Networks and Collaboration*
- *Supply Chain Performance Assessment*
- *Risk and Visibility*
- *Supply Chain Dynamics and Inventory Management*
- *Decision Support Systems and ICT in Supply Chains*
- *Environmental Sustainability and Green Logistics*
- *Management of the Customer-Supplier Relationship*
- *Design Configuration of Supply Chains*
- *Reverse Logistics*
- *Transport, Distribution and Third/Fourth Party Logistics*

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 2010

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LIFE-CYCLE ORIENTED POSTPONEMENT IN INTERNATIONAL SUPPLY CHAINS

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ABSTRACT

In order to lower costs, inventory levels, and transportation efforts while still being responsive to customer needs, it is beneficial to retain a product in a neutral product status in a supply chain as long as possible. Therefore, the placement of the order penetration point (OPP)[1] is a key decision in supply chain design since the product will be differentiated according to the customers' requirements after the OPP.

Despite a great number of publications on postponement, a practically applicable method for the right placement of OPP is still missing, let alone for the global context of automotive supply chains which extend to such distinct markets as the Brazilian and the German one.

Based on a literature review this paper shows how research should be conducted in order to develop a method for the placement of the OPP in global automotive supply chains by the example of Brazil and Germany over a complete product life-cycle. In order to do this, it is essential to consider current and future challenges within this topic and to align research with these challenges.

INTRODUCTION

Supply Chain design aims at designing supply, production and distribution networks in a manner that on the one hand all kinds of costs (production costs, transportation costs, inventory costs, etc.) are reduced and on the other hand the levels of service and reliability in the network (delivery time, delivery time reliability etc.) are increased. One of the decisions in supply chain design is the positioning of the order penetration point (OPP). The OPP defines from where on a product will be produced according to an actual customer order and to which point the production occurs anonymously into an inventory.

From an academic perspective, during the last years many publications have investigated the potential of different OPP positions and strategies. Here, full speculation, manufacturing postponement, logistics postponement, and full postponement are discussed [6]. It is possible to link these postponement strategies with logistical concepts (Figure 1). In postponement literature the benefits of delaying the customisation of a product as long as possible are described (shifting the OPP to the customer, i.e. downstream). In the Make-to-Order and Mass Customization literature, many examples and cases of a more customer specific production (shifting the OPP to the supplier, i.e. upstream) are discussed. All concepts agree on the importance of the issue of positioning the OPP, but none of them could yet deliver a structured approach to the actually position of the OPP based on specific product, process and market requirements. From an industrial perspective, the placement of OPP typically depends on the intuition and experience of managers. This is not a satisfactory approach considering the strategic impact of these decisions. In addition to this, the importance of this

[1] some authors [1] [2] [3] use for OPP the term decoupling point whereas some others [4] [5] use the term customer decoupling point.

decision becomes more obvious when OPP decisions have to be reconsidered for the different phases in a product life-cycle with their varying logistical requirements and within the current global context of many supply chains (e.g. the automotive one) [6] [7].

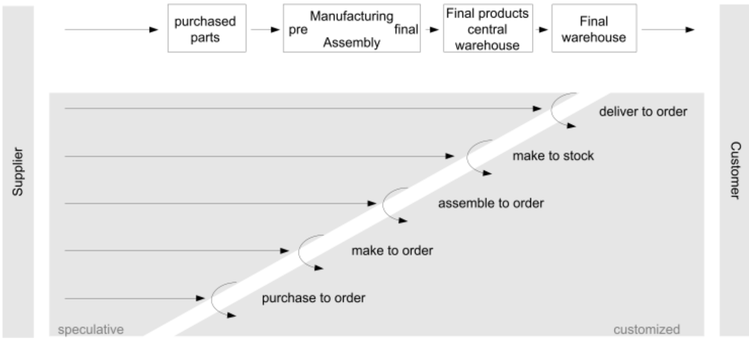

Figure 1: Different OPP along the supply chain (according to [5] [8])

The development of methods for the placement of the OPP is embedded in the research into postponement strategies in supply chain management. Traditionally, two aspects regarding postponement strategies have been distinguished [9] [6] [10]. On the one hand, postponement can refer to the manufacturing process itself. In this case, differentiation adverts to the actual product characteristics. Postponement, on the other hand, can be related to inventory location. The delivery of a product to a regional warehouse or even a point of sale may be postponed until a customer places an order. In this case, changes in inventory location are postponed to the latest possible point and inventory is kept centrally. A company can follow a converse strategy by speculating on a sale in a specific location and shipping the product in advance and storing it decentrally.

In order to conduct research for the right placement of the OPP effectively the remainder of the paper is structured in general challenges within the OPP on the one hand and presentation of the strategy of developing a method for the specific placement of the OPP guided by these challenges on the other hand. Finally, this is followed by a conclusion.

GENERAL CHALLENGES IN THE CONTEXT OF OPP

In 2001, Van Hoek [10] published a well received paper in which he reviewed the postponement literature prior to 1999 and identified challenges for future postponement research. The scientific progress on these challenges hitherto was presented by Boone et al [11]. Furthermore, based on their extensive literature review, they defined new challenges to postponement research:

- Challenge 1: Postponement as a supply chain concept
- Challenge 2: Integrating related supply chain concepts
- Challenge 3: Postponement in the globalising supply chain
- Challenge 4: Postponement in the customised supply chain
- Challenge 5: Assess application of postponement relative to performance
- Challenge 6: Selecting appropriate postponement points depending on the product life-cycle
- Challenge 7: Methodical upgrading of postponement
- Challenge 8: Investigate postponement implementation

These general challenges serve as a basis for the development of a model for the placement of OPP.

DEVELOPING A METHOD FOR THE PLACEMENT OF OPP

In order to measure the life-cycle oriented placement of the OPP in international supply chains, it is essential to consider the abovementioned challenges. Therefore, the research strategy for developing a method for the specific placement of the OPP in supply chains between Brazil and Germany is guided by these challenges.

Research strategy

Within this context, the research aim is to develop a dynamic method for the placement of OPP in global supply chains over a complete product life-cycle considering a systematic investigation on the influence of product diversity, resource flexibility under a supply chain perspective and the process adaptation of manufacturing processes along the supply chain (Figure 2). The research areas product diversity and resource flexibility comprise many of the relevant factors that influence the placement of the OPP but have not been regarded comprehensively yet.

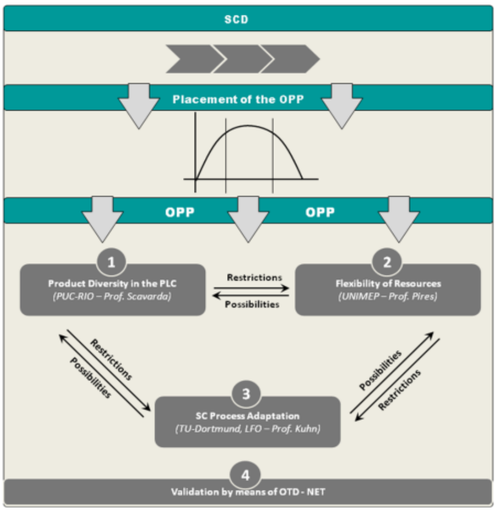

Figure 2: The research strategy

In the following subsections, the scientific state-of-the-art of these areas and the research questions will be presented referring to the abovementioned challenges.

Product diversity in the product life-cycle as specific answer to challenge 1

The product portfolio of a company is not only the most tangible result of an implicit or explicit corporate strategy, but also the single most important strategic factor for any production company. Moreover, the logistical complexity that is caused by considerable product diversity defines to which extent postponement strategies can be carried out at all.

Product Diversity (PD), also known as Product Variety, can be defined as the number of different versions of a product offered by a firm at a single point in time [12] and as the number of a different product offered to customers [13]. Demand for PD exists because consumers' preferences are often heterogeneous and because each individual consumer seeks variety in his/her acquisitions [14]. The trend of increasing this diversity has been observed across many industrial sectors [15], including fashion [16] [17], plastic packages [18], computers [19] [20], and automotive [21] [22] [23].

On the one hand PD can increase market share, raise revenue, enhance profitability, create a barrier to entry against new competitors, and satisfy more closely consumer needs [24] [13] [25] [26] [14] [17] on the other hand PD can also increase product development, procurement, production, and distribution costs, enhance demand uncertainty, and increase inventory and complexity along the whole supply chain [19] [26] [10] [17]. Therefore, PD proliferation can be referred as a "double-edged strategy" [19] that has been requiring innovative supply chain solutions [23] marking a key trade-off at the operations-marketing interface [27]. The managerial challenge is how to provide a high degree of diversity offering customised products with affordable prices [28]. The need for this efficient provision has been identified as a means of creating competitive advantage [13] [18]. This problem is even more complex if one considers the fact that diversity is closely related to the product life-cycle and that it varies according to each phase [29].

According to the first challenge (Chapter 0) the research field of product diversity in the life-cycle of a product has two main research questions:

- How firms manage their product diversity?
- Where product diversity should be generated in the supply chain?

Firstly, there has to be an investigation from a supply chain perspective how firms manage their product diversity. The main input should come from the academic literature and from the industry by plant visits in Brazil and in Germany.

Once the first goal is achieved, the next one is to define general mechanisms by which firms can manage product diversity under a supply chain perspective along the product life-cycle helping the understanding of where should PD be generated in the supply chain and its relation with the OPP. The research method for this area is exploratory and theory-building [30].

Resource flexibility as specific answer to challenge 2 and 3

According to the second challenge (chapter 0) the available resources have to be regarded systematically, since the qualitative and quantitative flexibility of available resources confine the feasibility of postponement strategies.

Over the past two decades competition has shifted from individual firms to whole supply chains [31] [32]. Accordingly, some of the key debates in the operations management domain have extended their scope beyond a single manufacturing system to include supply chain partners and their interactions. One example for such an extension is the recent topic of supply chain. This topic is relatively new with the first contributions appearing in the late 1990s [33]. The basic idea behind the extension of the flexibility debate into supply chains can be described in the words of Lummus et al [34] in that it "involves looking at those components that make an organisation flexible and [extending] them beyond the organisation's boundaries to other nodes in the supply chain".

Over the years numerous contributions have been made to the flexibility debate, adding important aspects to the concept itself. So far, five key aspects of flexibility have been pointed out; these are: (1) its (external and internal) types [35] [36] [37], (2) its dimensions [35] [36] [38], (3) the timeframe it refers to [39] [36], (4) the way in which it is used [40], and (5) whether it refers to a system's potential or its demonstrated state [35] [36].

From a supply chain perspective, the flexibility concept with its five key aspects may be complemented by a range of inter-organisational flexibility types. For example, in their literature review Stevenson & Spring [41] identify a number of flexibility types that are important on a supply chain level. These include re-configuration flexibility (i.e. the "potential to re-align or re-invent the supply chain"), relationship flexibility (i.e. the "ability to build collaborative relationships both up and downstream"), and logistics flexibility (i.e. the "potential to rapidly send and receive products cost-efficiently"). While Stevenson & Spring [41] do not attempt to classify these new flexibility types, it is obvious that they all constitute internal types of flexibility, because the end customer does not care how the supply chain manages to be flexible (e.g. through adding new partners when required or through linking the existing partners by flexible logistics concepts). The customer's concern still lies on the four external types (product, mix, volume or delivery arrangements), i.e. whether the supply chain can introduce novel products or change its output according to the customer's requirements.

Given the importance of flexibility (and associated characteristics like speed and product variety) for achieving a competitive advantage [24], it is unsurprising that researchers increasingly study how entire supply chains can deliver flexibility to their customers. However, the current debate is still in its infancy, and a recent literature review on the topic [41] has highlighted various avenues for future research. Inter alia, Stevenson & Spring [41] criticised the lack of empirical multi-tier studies capable of investigating the inter-organisational components of supply chain flexibility.

It is here that further research should attempt to make a contribution to the ongoing debate by examining the constraints in a supply chain at various tiers that limit the chain's ability to provide flexibility to its end customers. In particular, following questions are addressed:

- How contribute the various supply chain members to the flexibility of the overall chain?
- How can the decisions about the structure of a supply chain limit its ability to provide flexibility to its end customers?
- How true the hypothesis that the more downstream the OPP is, the more flexible the chain should be?
- How much does the position of the OPP depend on the supply chain members' relationships?

In this context the differences across countries and continents have to be considered (challenge 3; Chapter 0). In addition to advancing the academic debate on flexibility at a supply chain level by investigating the – so far under-researched – inter-organisational dimension of flexibility, these research questions are particularly relevant to practitioners. With the increasing synchronisation of supply chains, this topic is crucial for supply chain managers across most industries.

Process Adaptation as specific answer to challenges 4 and 5

The ideal placement of the OPP in a customised supply chain is rather challenging due to the multitude of specific influencing factors that have to be taken into account [42] [6]. Moreover, the influence of most of these factors such as inventory costs, multiple usage of parts, production and delivery lead times, forecasting quality, obsolescence risks of products and parts depends strongly on production, product and market characteristics. These characteristics however, are not static but vary themselves over the different product life-cycle phases [43]. According to the key challenges 4 and 5 following research question will be answered:

- Which influencing factors exist in the global context that impact the OPP?
- How can the customisation of the supply chains be realised?
- How the performance of current and potential future supply chain processes has to be measured?

According to the corresponding key challenge 5 (chapter 0), the performance of current and potential future supply chain processes has to be measured systematically by means of a framework of key performance indicators and an valuation method has to be implemented that allows for an integration of strategic product as well as resource flexibility related factors derived from the steps mentioned above into the key performance framework.

Validation as specific answer to challenges 6-8

The structure of a supply chain and its processes are the outcome of the application of a supply chain design method. Within a given topology and with a given product portfolio, not only the optimal placement of the OPP has to be identified in a systematic way, but also the implications of adapting processes, for instance from a make-to-order to a make-to-stock setting.

Furthermore, feasible design options regarding the OPP placement have to be identified by a parametric model of the supply chain structure, its possible processes and the underlying product portfolio and resource flexibility. Moreover, a method has to be developed to define the adequate placement of the OPP. In this context, following research questions have to be considered:

- How can different appropriate OPP be selected?
- How can the method be validated?
- How can the method be implemented in a real world supply chain?

According to the challenge 6 (Chapter 0), one of the key decisions in designing a supply chain is the placement of the OPP [42] since both cost and service levels in a supply chain are strongly influenced by this decision [44] [45]. On the one hand, placing the OPP more closely to the supplier, i.e., upstream, increases delivery lead times since more (customer specific) production and transportation steps have to be carried out. On the other hand, placing the OPP more closely to the final customer, i.e., downstream, reduces the delivery lead time. This, however, is offset by higher inventory costs [42] [11] [16].

The method should include the transformation of processes mentioned above. In addition to this, it should meet several requirements. Firstly, it has to consider all relevant influencing factors for the OPP decision (including market, product, process and life-cycle related factors). Secondly, it has to consider the effect of these factors in a quantitative way. Merely indicating qualitative tendencies does not suffice. Thirdly, it has to consider dynamic behaviour of market, product and process conditions in the network and not only static average values. Eventually, the method should be capable of working with an elevated and realistic number of products, parts, customers, network partners and transport relations in a supply chain.

According to challenge 7 (Chapter 0) the best feasible way of validating complex supply chain design decisions such as the placement of the OPP in a dynamic environment is discrete event simulation. A sophisticated, proven software tool for dynamic simulation with an excellent track record in research as well as industrial practice that will be used in this context is OTD-NET [46].

Finally, the developed and validated method has to be implemented (challenge 8: Chapter 0) by the example of an automotive supply chain which especially goes from Brazil to Germany, and vice versa, in order to show its feasibility.

CONCLUSION AND OUTLOOK

In order to develop a method for the specific placement of the OPP in global automotive supply chains by the example of Brazil and Germany over a complete product life-cycle it is vital to consider the current and future challenges regarding research about the order penetration point. The presented research strategy is guided by these key challenges. The method which will be developed for the life-cycle oriented placement of the OPP in international supply chains meets all challenges drawn up by Van Hoek [10] and Boone et al [11].

The next steps will be the successive response to the research questions of the distinct areas. Hence, not only several gaps in academic literature will be addressed, but a practically applicable method for one of the major issues in industrial supply chain management, OPP placement, can be derived.

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REFERENCES

[1] Naylor, J. B., Naim, M. M., Berry, D.: Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain. International Journal of Production Economics, 62, pp. 108-118. 1999.

[2] Yang, B. & Burns, N.: Implications of postponement for the supply chain. In: International Journal of Production Research, Vol. 41, No. 9, pp.2075-2090. 2003.

[3] Sharman, G.: The rediscovery of logistics. Harvard Business Review, 62, pp. 71-79. 1984.

[4] Van Hoek, R. I.: Postponed manufacturing: a case study in the food supply chain. Supply Chain Management, 2, pp. 63-75. 1997.

[5] Hoekstra, S. & Romme, J. (Eds.): „Integral Logistic Structures: Developing Customer-Oriented Goods Flow", McGraw-hill, London. 1992.

[6] Pagh, J.D. & Cooper, M.C.: Supply chain post ponement and speculation strategies: How to choose the right strategy. In: Journal of Business Logistics, Vol. 19, No. 2, pp.13–33. 1998.

[7] Bowersox, D. J. & Closs D. J.: Logistical Management: The Integrated Supply Chain Process. McGraw-Hill Series in Marketing. New York: McGraw-Hill. 1996.

[8] Pfohl, H.-C.: Logistik-Management. Berlin: Springer. 1994

[9] Zinn, W. & Bowersox, D.: Planning physical distribution with the principle of postponement. In: Journal of Business Logistics, Vol. 9, No. 2, pp. 117. 1988.

[10] Van Hoek, R.: The rediscovery of postponement a literature review and directions for research. In: Journal of Operations Management. 2001.

[11] Boone, C. A.; Craighead, C. W. & Hanna, J. B. (2007): Postponement: an evolving supply chain concept. In: International Journal of Physical Distribution & Logistics Management, 2007, Vol. 37, No. 8, pp.594-611.

[12] Randall, T.; Netessine, S. & Rudi, N. (2006): An Empirical Examination of the Decision to Invest in Fulfillment Capabilities: A Study of Internet Retailers. In: Management Science, Vol. 52, No. 4, pp. 567-580, 2006.

[13] Pine II, B. J. (1993): Mass Customisation, the New Frontier in Business Competition, Harvard Business School Press, Boston, MA.

[14] Tang, Ester P. & Yam, Richard (1996): Product Variety Strategy – An Environmental Perspective. In: Integrated Manufacturing Systems, Vol.7, No.6, pp. 24-29, 1996.

[15] Polo, E. & Chernatony, L.(2008): Effect Of Brand Extension Strategies On Brand Image A Comparative Study Of The UK And Spanish Markets. In: International Marketing Review, Vol. 25, No.1, pp. 107-137, 2008.

[16] Fisher, M. L. (1997): What is the Right Supply Chain for your Product? In: Harvard, Business Review, March/April 1997.

[17] Vaagen, H. & Wallace, S.W. (2008): Product variety arising from hedging in the fashion supply chains. In: International Journal of Production Economics, Vol. 114, No. 2, pp. 431-455.

[18] Da Silveira, Giovani (1998): A framework for the management of product variety. In: International Journal of Operations & Production Management, Vol.18, No.3, pp.271-285, 1998.

[19] Bayus, B.L. & Putsis Jr, W.P., (1999): Product proliferation: An empirical analysis of product line determinants and market outcomes. In: Marketing Science Vol.18, No.2, pp.137-153.

[20] Hui, Kay-Lung (2004): Product Variety Under Brand Influence: An Empirical Investigation of Personal Computer Demand. In: Management Science, Vol. 50, No. 5, pp.686-700, 2004.

[21] Pil, F. & Holweg, M. (2004): Linking Product Variety to Order-Fulfillment Strategies. In: Interfaces, Vol. 34, No. 5, pp. 394-403.

[22] Scavarda, L.F.; Barbosa, T.P.W. & Hamacher, S.(2005): Comparação entre as Tendências e Estratégias da Indústria Automotiva no Brasil e na Europa, Gestão & Produção, Vol.12, No. 3, pp. 361-375.

[23] Scavarda, L.F.; Schaffer, J.; Carmo, A.J.R.R.S.; Reis, A.C. & Schleich, H.(2009): Product Variety: An Auto Industry Analysis and a Benchmarking Study. Benchmarking. In: An International Journal, Forthcoming - v. 16 n. 3 de 2009.

[24] Kekre, S. & Srinivasan, K. (1990): Broader product line: a necessity to achieve success? In: Management Science, Vol. 36, No. 10, pp. 1216-1232.

[25] Quelch, J.A., & Kenny, D. (1994): Extend profits, not product lines. In: Harvard Business Review, Vol. 72, No. 5, pp. 153-160.

[26] Berry, W. & Cooper, M. (1999): Manufacturing flexibility: methods for measuring the impact of product variety on performance in process industries. In: Journal of Operations Management, Vol. 17, No. 2, pp. 163-178.

[27] Shapiro, B.P. (1977): Can marketing and manufacturing coexist? In: Harvard Business Review, Vol 55 No 5, pp. 104-114.

[28] Schaffer, J. & Schleich, H. (2008): Complexity Cost management, Parry, G./ Graves, A. (Eds) Build To Order: The Road to the 5-day Car, Springer London, London, pp. 155- 174.

[29] Kotler, P.; Keller, K.L. & Keller, K. (2008), Marketing Management, Prentice Hall.

[30] Meredith, J. (1998): Building operations management theory through case and field research. In: Journal of Operations Management, Vol. 16, No. 4, pp. 441-454.

[31] Lambert, D.M. & Cooper, M. (2000): Issues in Supply chain management. In: Industrial Marketing Management, Vol. 29, No. 2, pp. 1-19.

[32] Christopher, M. (2005): Logistics and supply chain management: creating value-adding networks (3rd ed.), FT Prentice Hall, Harlow.

[33] Vickery, S.K.; Calantone, R. & Droge, C. (1999): Supply chain flexibility: an empirical study. In: Journal of Supply Chain Management: A Global Review of Purchasing & Supply, Vol. 35, No 3, pp. 16-23.

[34] Lummus, R.R.; Duclos, L.K. & Vokurka, R.J. (2003): Supply chain flexibility: building a new model. In: Global Journal of Flexible Systems Management, Vol. 4, No. 4, pp. 1-13.

[35] Slack, N. (1987): The flexibility of manufacturing systems. In: International Journal of Operations & Production Management, Vol. 7, No. 4, pp. 35-45.

[36] Upton, D.M. (1994): The management of manufacturing flexibility. In: California Management Review, Vol. 36, No. 2, pp. 72-89.

[37] Gupta, Y.P. & Somers, T.M. (1996): Business strategy, manufacturing flexibility, and organizational performance relationships: a path analysis approach. In: Production and Operations Management, Vol. 5, No. 3, pp. 204-233.

[38] Koste, L.L.; Malhotra, M.K. & Sharma, S. (2004): Measuring dimensions of manufacturing flexibility. In: Journal of Operations Manag., Vol. 22, No. 2, pp. 171-196.

[39] Zelenović, D.M. (1982): Flexibility - a condition for effective production systems. In: International Journal of Production Research, Vol. 20, No. 3, pp. 319-337.

[40] Gerwin, D. (1993): Manufacturing flexibility: a strategic perspective. In: Management Science, Vol. 39, No 4, pp. 395-410.

[41] Stevenson, M. & Spring, M. (2007): Flexibility from a supply chain perspective: definition and review. In: International Journal of Operations & Production Management, Vol. 27, No. 7, pp. 685-713.

[42] Olhager, J.: Strategic Positioning of the Order Penetration Point. In: International Journal of Production Economics, Vol. 85, No. 3, pp.319-329. 2003.

[43] Alscher, J. & Schneider, H.: Zur Interdependenz von Fehlmengenkosten und Servicegrad. In: krp 1982, pp. 257-271. 1982.

[44] Zäpfel, G.: Grundzüge des Produktions- und Logistikmanagements, 2. unwesentlich veränd. Aufl. München; Wien: Oldenburg. 2001.

[45] Schönsleben, P.: Integrales Logistikmanagement: Planung und Steuerung von umfassenden Geschäftsprozessen. Springer, Berlin. 2004

[46] Schwede, C.; Song, Y.; Sieben, B.; Hellingrath, B., Wagenitz A.: A Simulation-based Method for the Design of Supply Strategies to Enter Developing Markets. In: Proceedings of the Seventh International Workshop on Modelling and Applied Simulation, September 2008, Ampora San Giovanni, Amantea (CS), Italy, 83-92. 2008.

IMPLICATIONS FOR JIT/LEAN MANUFACTURING IN THE EGYPTIAN MARKET

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1. INTRODUCTION

With global pressures, shrinking margins, and increasing competitiveness, organizations continue to struggle for increased return on investment (ROI)[2] (Dejule, 2007). Research has proven that ROI will be reaped by organizations with manufacturing flexibility allowing them to better capitalize on changing market demands (Gubata, 2008). Logistics plays a major role as it can facilitate or hinder the efficient and cost effective flow of materials through the supply chain.

Since Toyota implemented JIT (Just-in-time) production of automobiles in 1938, many manufacturers have adopted techniques of lean manufacturing on different scales (Connaughton, 2008). JIT is the name used to describe a manufacturing system where necessary parts to complete finished products are produced or delivered at the assembly site as needed (Wafa & Yasin, 1998). Its goal is to eliminate all forms of waste (Peters & Austin, 1995). Its objective is to better utilize capital under frequently changing market demands (Connaughton, 2008). This would explain why so many organizations worldwide are striving to integrate it into their production systems. A recent US survey, jointly conducted by Industry Week and Manufacturing Performance Institute for 2006 consensus, showed that 43% of the total respondents as currently applying JIT (Gubata, 2008). A research by Wafa & Yasin, 1998, has shown that a JIT organizational philosophy has the potential to improve organizational efficiency and effectiveness.
This raises a question regarding the situation in Egypt; If JIT and lean systems reap so many benefits, where does Egypt stand in the global market? A lack of empirical research on this topic with a specific application to Egypt is eminent. The purpose of this research is to highlight the degree of JIT application in Egypt and to identify reasons for its lag in contrast to the global market.

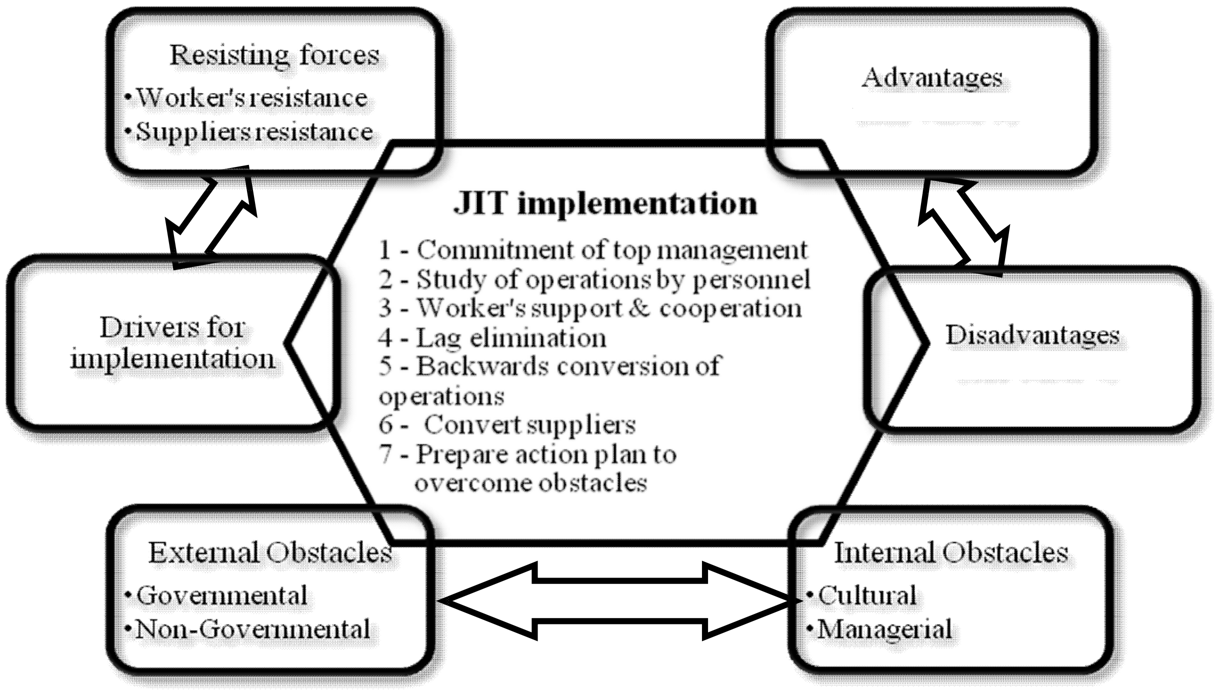
2. LITERATURE REVIEW

In JIT implementation, the external and internal obstacles that exist are to be resolved first (Wafa & Yasin, 1998), see figure 1. The external obstacles can be either governmental; such as tariffs on imported goods and national infrastructure, or non-governmental; such as culture and mentality of customers and intermediate retailers (Salaheldin, 2003). When obstacles are overcome, the driving forces that would cause an organization to apply JIT are realized. These forces are then weighed against the resisting forces which are broken down into several sections. The most pertinent of these sections is the resistance of workers and suppliers. The results are then compared to the benefits and drawbacks of JIT implementation. The benefits include; closeness to/higher degree of trust with suppliers (lee & Wellan, 1993); increased quality of information and faster detection of defects (Allers & Lambert 1995); improved performance in lead times, quality levels, labor productivity, employee relations and inventory levels (Connaughton, 2008). As for the drawbacks; personnel may find difficulty in adjusting to the new relationships (Peters & Austin, 1995); the lack of communication upstream and downstream may cause hindrance (Broyles, et al 2005); the increased dependence on timely delivery of components to production line renders the organization open to greater disruptions (Gabuta, 2008). Finally, in order to apply

[2] ROI is Return On Invested capital: the amount, expressed as a percentage, and is earned on a company's total capital

JIT, the organization must go through the 7 steps of JIT implementation identified by several researches in the field such as Broyles, et al, 2005.

Figure 3 - Hypothetical model for forces affecting JIT implementation



It is difficult to generalize the benefits and drawbacks of JIT/lean application, especially since this application may have implications on different areas of an organization. However, as most literature has proven, every organization is a unique case. Thus the advantages and disadvantages are highlighted by literature and case studies, each organization can then relate to them as best as they can, taking alterations as needed. Several conclusions regarding the current application and barriers to implementation of JIT have been identified in researches about the United States and Egypt. These shall be further discussed in the findings section.

3. METHODOLOGY

In order to analyze the topic more extensively, two hypotheses were formulated. Those were established to answer the following research question; why is Egypt lagging behind the global market in adopting JIT systems and integrating it into its organizations? This was researched in both the Industrial and Service sectors.

First Hypothesis was: H_0 - Egyptian organizations are not willing to apply JIT in the near future. H_1 - Egyptian organizations are willing to apply JIT in the near future.

Second Hypothesis was: H_0 - Egyptian organizations perceive negative economic impact of JIT. H_1 - Egyptian organizations perceive positive economic impact of JIT.

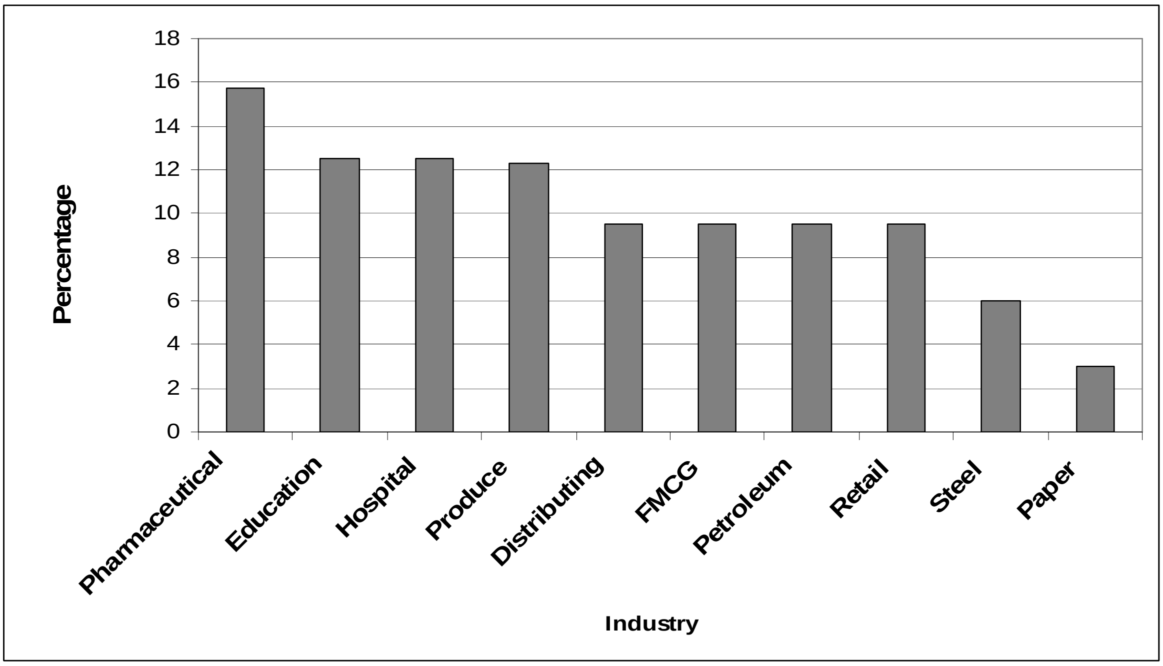
4. QUESTIONNAIRE

The development of the research instrument was based mainly on new scale development. This was because no past studies were identified that directly address all of the issues within the scope of this research. Several company executives, directly responsible for the production process and inventory management, were interviewed. The outcomes of these interviews were used to form two focus groups; each composed of three individuals from different organizations in order to further develop the knowledge base acquired. This then facilitated the construction of a questionnaire. The questionnaire consisted of qualitative and quantitative issues to provide greater insights into the topic. This was to define the Egyptian knowledge of JIT system, methodologies for application, and currently experienced obstacles. The criteria identified within the questionnaire were accumulated through the literature. Upon the completion of the questionnaire, it was relayed to the persons, who had been interviewed in the construction phase, and after several modifications, the questionnaire was validated by 4 face-to-face interviews. Final adjustments were made as per recommendations, and the questionnaire in its final form was distributed to personnel and managers in both industrial and retail sectors. The completed questionnaire yielded a response rate of 43.2% which is relatively acceptable in comparison to similar researches conducted in Egypt and internationally.

5. ANALYSIS

The data gathered was analyzed using SPSS software package that yielded the following results. Figure 2 illustrates the percentages of surveyed organizations. The hospital and education sectors have been analyzed in terms of service delivery and procurement. Other sectors were analyzed in terms of procurement, product delivery and transportation throughout the supply chain.

Figure 2 - Industries of Organizations Surveyed



5.1 Proof of First Hypothesis:

As per table 1, a total of 75% of the responses indicated that they did not have any JIT relationships at this point in time, and are not willing to apply JIT in the near future. 18.6% are willing to apply JIT while only 9.4% have some form of JIT relationship.

Table 1 - Cross Tabular Analysis for 1st Hypothesis

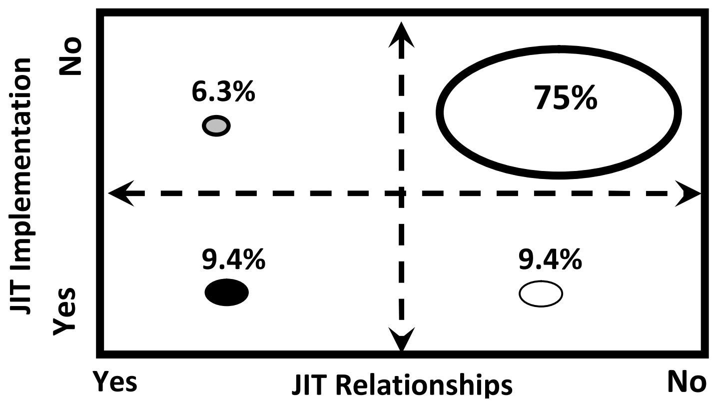
			Implementation		Total
			Yes	No	
JIT relationships	Yes	% of Total	9.4%	6.3%	15.6%
	No	% of Total	9.4%	75.0%	84.4%
Total		% of Total	18.8%	81.3%	100.0%

In Table 2, the two-sided asymptotic significance is less than 0.1 by a considerable amount; this means that the changes are not due to chance variation with an exact significance of 0.034 which is less than 0.05. Figure 3 indicates that 75% of the respondents do not have any JIT relationships currently and are not prepared for any JIT implementations soon, while only 9.4% either have or do not have JIT relationships but are willing to apply it. The major reason for this is due to the insufficient literacy of the Egyptian organizations and the presence of several obstacles that have been highlighted in the literature of this research. This diagram shows the acceptance of the null hypothesis (H_0) such that Egyptian organizations currently do not have any JIT relationships and are not willing to apply JIT in the near future until the majority of the obstacles are resolved, the most pertinent of which are both the logistics and modes of transportation problems.

Table 2 - Chi Square Test for First Hypothesis

	Value	df	Asymp. Sig (2-sided)	Exact Sig (2-sided)	Exact Sig (1-sided)
Pearson Chi-Square	6.619(b)	1	.010		
Continuity Correction(a)	3.799	1	.051		
Likelihood Ratio	5.318	1	.021		
Fisher's Exact Test				.034	.034
Linear-by-Linear Association	6.412	1	.011		
N of Valid Cases	32				

Figure 3 - Matrix of JIT Relationships vs. JIT Implementation Cross Tabulation



5.2 Proof of Second Hypothesis:

The two-sided asymptotic significance of the chi square analysis shown in table 3 is greater than 0.1. This indicates that the variations are due to chance, and thus all organizations are willing to apply JIT once the obstacles to implementation are removed. This indicates that the majority of the organizations perceive positive economic impact of JIT implementation. Table 4 is the second hypothesis cross tabulation. As is evident in the table, the majority of the organizations exist in the "agree" area for the need for more information. Also, most of the organizations that perceive positive economic impact of JIT implementation exist in the same region. This proves the second hypothesis and means that organizations need more information to apply JIT, but they perceive positive results post-implementation.

Table 3 - Chi-Square Tests for Second Hypothesis

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.954(a)	16	.115
Likelihood Ratio	16.007	16	.453
Linear-by-Linear Association	.486	1	.486
N of Valid Cases	31		

Table 4 - More Information vs. Positive Economic Impact of JIT Graph

<table>
<tr><th colspan="3" rowspan="2"></th><th colspan="5">More information</th><th rowspan="2">Total</th></tr>
<tr><th>Totally Disagree</th><th>Disagree</th><th>Neutral</th><th>Agree</th><th>Strongly Agree</th></tr>
<tr><td rowspan="6">Economic Impact of JIT</td><td>Don't Know</td><td>% of Total</td><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>3.1%</td><td>3.1%</td></tr>
<tr><td>Totally Disagree</td><td>% of Total</td><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>0.0%</td><td>3.1%</td><td>3.1%</td></tr>
<tr><td>Disagree</td><td>% of Total</td><td>3.1%</td><td>0.0%</td><td>0.0%</td><td>3.1%</td><td>0.0%</td><td>6.2%</td></tr>
<tr><td>Neutral</td><td>% of Total</td><td>0.0%</td><td>3.1%</td><td>3.1%</td><td>3.1%</td><td>12.5%</td><td>21.9%</td></tr>
<tr><td>Agree</td><td>% of Total</td><td>0.0%</td><td>3.1%</td><td>3.1%</td><td>9.4%</td><td>15.6%</td><td>31.3%</td></tr>
<tr><td>Strongly Agree</td><td>% of Total</td><td>0.0%</td><td>0.0%</td><td>3.1%</td><td>21.9%</td><td>9.4%</td><td>34.4%</td></tr>
<tr><td colspan="2">Total</td><td>% of Total</td><td>3.1%</td><td>6.3%</td><td>9.3%</td><td>37.5%</td><td>43.7%</td><td>100%</td></tr>
</table>

According to the survey of JIT implementations within US manufacturers conducted by White et al, (1999), several findings were established. Amongst these findings, an average of 71% of respondents had implemented some sort of JIT practice. The research also identified that these organizations had a mean time since JIT implementation of approximately 2.12 years. This dates as far back as 1996, while Egyptian manufacturers still lag behind in 2009. These findings were also supported with an average of 72.1% who indicated post JIT implementation performance improvement. These findings are in agreement with previous researches such as Baldwin, 1989 and Fawcett & Pearson, 1990, with a special indication that larger manufacturing firms are more likely to implement JIT practices and lean systems. As for the analysis of JIT purchasing by Mistry, et al (1996), their results show a reduction of inventory of 65.1%. This is alongside a rate of improved quality for incoming materials of 39.5% with an overall reduction in scrap costs of 32.6%.

Salaheldin & Eid (2007) pointed out that Egyptian manufacturers are less competitive in the implementation of World Class Manufacturing (WCM) techniques; of which JIT and Lean systems are major elements. They also concluded that Egyptian manufacturers tend to apply "*older techniques that lie under the umbrella of mass production approach*." This indicates that they haven't been enlightened by the new world class theme of mass customization. It has also been established that the most modern manufacturing practices established in the 1990s were least applied by Egyptian manufacturers. This, once again, indicates the presence of a technological gap between Egyptian and world class manufacturers. The research had also concluded that the lack of awareness of Egyptian manufacturers will guarantee that the gap will increase. These findings are in line with the findings established from the statistical analysis conducted in this research. Therefore, it is a must that the majority of the obstacles are resolved in order to facilitate the presence of Egypt on the scale in international competitiveness.

6. DISCUSSION

6.1 Research Limitations

Throughout the research, several obstacles were encountered that have been regarded as limitations to the research. The first was the inadequate number of researches about JIT/Lean systems in Egypt causing insufficient in-depth data gathering. The second was that the degree of comprehension of JIT and Lean manufacturing in Egypt was minimal. The third was due to the fact that most Egyptian organizations regarded the information required for the research as "Classified Data[3]".

6.2 Conclusion

Bureaucracy and inflexibility play a major role in hindering the modernization of Egyptian firms, and consequently, the burden and stress on the suppliers and producers increases to be able to fulfill orders on time. This also increases due to the ambiguity of the market which causes difficulty in the implementation of demand forecasting. Also the logistics and transportation modes are incompetent and thus hinder production processes. This raises the need for the retention of huge inventory levels.

The major issue that lies within Egyptian organizations is the culture and the chronic transportation/ traffic problems in Egypt, which has a basis for failure to comply to the time frames and schedules. This is while the procedures are tedious with an exhaustive structural framework which is never pre-determined. This has led to increasing the complexity of the situation for all members of the supply chain, which is more evident in

[3] Classified data is information that is declared unavailable to the public for security reasons

"tangled webs" of supply chains; where each supplier provides to numerous retailers, and each retailer relies on more than one supplier.

Although several organizations seek to apply JIT or are willing to apply it, the aftermath required in order to convert all supplier and customer tiers does not appeal to the organizations. Moreover, the bureaucracy and redundancy currently existing within the legal systems and the ports of entry, pose a threat and difficulty for all industries within Egypt, making it almost impossible to handle JIT/Lean manufacturing strategies.

6.3 Future Research

In order to further address the issue of JIT and lean operations alongside facilitating the technological advancement of operations in Egypt, Egyptian organizations must be made aware of the advantages to be reaped. Future research should identify the JIT philosophies and approaches. It should also focus on manufacturing industries in order to gain greater insights. Another major point of research would be through logistics' planning to overcome the chronic problem of traffic congestion for facilitating a smooth flow of truckloads throughout Egyptian roads. The culture, ethics, and moral conduct of business people must also be researched as these can act as obstacles facing transparency of information required between all members of the supply chain. Researchers are encouraged to further investigate these issues and their applicability within the Egyptian context.

7. REFERENCES

Alles, M., Datar, S., & Lambert, R. (1995). Moral Hazard and Management Control in Just-in-time Settings. Journal of Accounting Research , 33, 177-204.

Baldwin, R.E. (1989). Adaptive effects on purchaser-vendor relation- ships resulting from Japanese management technology. Proceedings of the National Purchasing and Materials Management Research Symposium, 42-54.

Broyles, D., Beims, J., Franko, J., & Bergman, M. (April, 2005). Just-In-Time Inventory Management Strategy & Lean Manufacturing; overview of just-in-time inventory management. Retrieved August 15, 2009, from academic mind: http://www.academicmind.com/unpublishedpapers/business/operationsmanagement/2005-04-000aaf-just-in-time-inventory-management.html

Connaughton, S. A. (2008). Lean Manufacturing. EBSCO - Research Starters.

Dejule, R. (2007). The Changing Supply Chain. Semiconductor International Journal , 61-70.

Fawcett, S. E., & J. N. Pearson. (1990). Requirements and Benefits of Implementing Just-In-Time Manufacturing for Small-Manufacturers. Journal of Small Business Strategy, 1(2), 10-26.

Gubata, J. (2008). Just-In-Time Manufacturing. EBSCO - Research Starters , 2-9.

Lee, H., & Wellan, D. (1993). Vendor Survey Plan: a selection strategy for JIT/TQM suppliers. International Journal of Physical Distribution & Logistics Management , 23 (7), 39-46.

Mistry, R., Gotcher, W., Radovilsky, Z., & Yip, R. (1996). JIT Purchasing: analyzing survey results. Industrial Management .

Peters, M., & Austin, J. (1995). The impact of JIT: a critical analysis. Industrial Management & Data Systems , 95 (1), 12-17.

Salaheldin, S. I., (2003). The Implementation of TQM Strategy in Egypt: a field-force analysis. The TQM Magazine, 15(4), 266-274.

Salaheldin, S. I., & Eid, R., (2007). The Implementation of World Class Manufacturing Techniques in Egyptian Manufacturing Firms: an empirical study. Industrial Management & Data Systems, 107 (4), 551-566.

Wafa, M. A., & Yasin, M. M., (1998). A Conceptual Framework for Effective Implementation of JIT: an empirical investigation. International Journal of Operations & Production Management, 18(11), 1111-1124.

White, R. E., Pearson, J. N., & Wilson, J. R. (1999). JIT Manufacturing: A Survey of Implementations in Small and Large U.S. Manufacturers. Management Science, 45 (1), 1-15.

PROPOSING A CONCEPTUAL FRAMEWORK OF RISK DISTRIBUTION IN THE SUPPLY CHAIN: A CRITICAL LITERATURE REVIEW

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ABSTRACT
The purpose of this paper is to propose a framework of risk distribution in the supply chain. The rationale behind the development of such framework was based on the lack of risk distribution strategy defined in prior supply chain studies. A critical literature review is a selected method to analyse and criticise the current literatures in order to develop a framework adding by developed definition from relevant literatures. This proposed framework will provide insights on how risk being distributed among supply chain members and benefit to business practitioners in term of alternative risk management strategies.

INTRODUCTION
Risk management becomes an important program to many organisations in the supply chain today. The prior studies present the growing importance of the concept of risk in supply chain and supply chain management (Juttner, et al, 2003; Juttner, 2005; Li and Zhao, 2009; Pujawan, Kurniati, and Wessiani, 2009; Thun and Hoenig, 2009; Mohan, Viswanadham, and Trikha, 2009; Faria, Nunes, and Matos, 2010). Many risk management strategies are proposed to reduce or mitigate risks, however, there is a gap for risk distribution tactic (Manuj and Mentzer, 2008a; Juttner, 2005; Hallikas, et al, 2004). The review of prior supply chain literatures also shows no clarification on both definition and framework for risk distribution strategy. This paper then seeks to fill the gaps by providing a definition and conceptual framework. The proposed framework will highlight key decision making for risk distribution strategy in order to achieve risk mitigation purpose. A critical literature review (Croom, Romano and Giannakis, 2000; Coley, 2008; Schoenherr, 2009) is a research method to critically analyse and develop an initial model of risk distribution framework for the supply chain from the current literatures.

RISK DISTRIBUTION
The concept of risk distribution strategy has not yet been widely referred to in prior researches. The search with key word of *Risk distribution* shows the number of articles published in previous years, as illustrated by table 1. Medical Science is the most referred context about risk distribution phenomenon, which is followed by natural and financial context.

	2000-2009	***1990-1999***	***1980-1989***	***UNDER 1979***
MEDICAL SCIENCE	*20*	*8*	*3*	*-*
NATURE	*10*	*1*	*-*	*1*
FINANCE	*8*	*4*	*-*	*-*
ASSET AND CONSTRUCTION	*4*	*-*	*-*	*-*
SUPPLY CHAIN	*1*	*-*	*1*	*2*
LAWS	*-*	*-*	*-*	*2*
OTHERS (E.G. SAFETY, MANUFACTURING, ETC.)	*18*	*6*	*3*	*4*
TOTAL	***57***	***19***	***7***	***9***

Table 1: Summary of risk distribution articles (as of December 2009)

The first article that referred to risk distribution was published in Laws (Steyer, et al., 1940). The article stated that risk distribution would impact the identification of the ownerships of liability under the Securities Act. "*Some Thoughts on Risk Distribution and the Law of Torts*" by Calabresi (1961) was cited the most by prior researchers. This article referred 3 meanings to risk distribution: (1) a spreading of losses, (2) burden of losses to be borne by those classes of people "most able" to pay, and (3) those enterprise who could give rise to a loss should bear the burden. These meanings are differently defined regarding to the law case example and help the judges to finalise the direction.

In the supply chain, the concept of risk distribution strategy was not expressly stated. As illustrated by table 1, there were 4 articles that referred to it, however, the most referred risk distribution publication focused on the perspective of the ownership of liability. The first article was found in 1964 which stated a distribution of maritime risk under the liability concerns (Anon., 1964). The maritime risk here was referred to the risk that occurred during transportation in the sea. The article discussed the impact on who should pay for insurance and liability if there was carriage damage even it was a proper delivery. Similar to another article in 1978, it considered the liability for hazardous material transport (Roberts, 1978). The problem would impact cargo insurance fees if there was no clear in responsibility. The responsibility should be distributed and written in the contractual agreement or any legal letters before purchase and sale deals. Insurance was stated as the cost effective method for a distribution of risk. It would do for an increasing knowledge about the insurance undertaken by laws (Forte, 1987). Recently, Ji, et al (2009) explained distribution of supply chain risk by using cooperative games of Shapley Value. The Shapley Value gives the stable solution and is widely used for profit allocation. The characteristics of risk distribution are explained as rational choices of enterprise and alliance in the supply chain.

To summarize, the above related literature highlighted the phenomenon of risk distribution about areas (Hay, et al., 2004; Caballero, Beltran, and Velasco, 2007) and parties/members (Ford, Giles, and Mokdad, 2004; McMichael, 1989; Choiniere, Lafontaine, and Edwards, 2000; Bartley, et al., 2000, Norozi, et al., 2006; Pollack, 2001; Gao, et al., 2001; Hyatt and Pesando, 1996; Ferguson and Peters, 1997) which risks being distributed to. The definition of risk distribution in the supply chain must be new developed based on the review of prior literatures, especially by Calabresi (1961) and Vassallo (2009). As a result, risk distribution in the supply chain is carried out by 2 critical characteristics:

1. Risk distribution is the phenomenon that the entire amount of particular risks from focal firm is broken into small units and then be distributed to two or more supply chain members

2. Risk distribution is the approach to mitigate risks by not altering firm practice

Risk distribution will not take place if one of above characteristics does not exist. Business practitioners will get benefit from risk distribution strategy as no need to change their current practice. However, they may face difficulty when justifying on which member suit to receive risks and the proper amount of distributed risks.

PROPOSED FRAMEWORK FOR RISK DISTRIBUTION IN THE SUPPLY CHIAN

This paper applied a critical literature review approach which is to critically analyse and criticise current related literature and identify gaps in the existing knowledge (Croom, Romano and Giannakis, 2000; Coley, 2008; Schoenherr, 2009). After the definition of risk distribution is developed, its framework will be drawn in the next step. A large number of risk management articles are critically explored and issued the underlying among their phenomenon and implementation process. To contrast, two characteristics of risk distribution: (1) many supply chain members involved and (2) not alter the firm practice, makes it differ from other risk management strategies such as risk sharing, risk transfer, and risk avoidance (Manuj and Mentzer, 2008a). Owing to 4 articles available for risk distribution in supply chain (as in table 1), the study of prior literatures is limited. In such case, the proposed framework will be developed by adding 2 groups of literatures: (1) risk distribution strategy from other contexts and (2) other risk management strategies. The critical analysis finalised with 3 relevant factors: (1) risk selection, (2) lack of risk handling ability, and (3) member selection, that causing to risk distribution manner.

Risk selection
Risk identification and risk evaluation are always referred as the first step to decide for risk management strategy (Manuj and Mentzer, 2008a). The selection of risks from risk evaluation stage is very essential as of many supply chain risks existed such as demand risk, supply risk, information risk, security risk, and operational risk (Manuj and Mentzer, 2008a). Each risk type has different phenomenon and characteristics. Risks are possible to link with each other and influence the other risk outcomes (Manuj and Mentzer, 2008b). Some risks are then very easy to handle, but not for the others. Or, some risks can be combined and managed at the same time. However, top ranking of risk exposure should be firstly mitigated to let firm reduce huge impact (Dupras, 2007). The empirical finding by Oke and Gopalakrishnan (2009) confirmed that the different risk management strategies were initially selected from risk type and level of risk exposure. Thus, it is very important to match risk type with risk management strategies to get benefits from risk management program (Ghoshal, 1987; Atkinson, 2005; Ng and Loosemore, 2006; Manuj and Mentzer, 2008b; Oke and Gopalakrishnan, 2009).

Lack of risk handling ability
Risk management strategy always requires firm to put effort by spending or change their practice, for example, educate customers for reducing demand risk or ask multiple sourcing strategies for reducing supply risk (Oke and Gopalakrishnan, 2009). These strategies require firm spend both time and cost to prepare and prompt for risk management implementation. The risk handling ability can categorise into 6 criteria: (1) technical/ production, (2) finance, (3) human resource, (4) infrastructures, and (5) leadership and strategy, to manage such risks (Lee, Lee and Wang, 2009; Mousakitis and Askounis, 2008; Kirby, 2006; Gunasekaran, Patel, and McGaughey 2004). The technical/production ability considers manufacturing or production process, including production capability, machine capacity, quality control, and supply continuity. Financial ability is concerned for any investments of both capital and operating expense to set up risk management strategy. Human resource ability scopes manpower skills and capacity, together with, training provided and recruitment criteria. Infrastructure or support ability counts for technology, information transfer, waste disposal capability, and network support. Leadership and strategy ability considers management and executive support for risk management, including innovation, legal support issue, and company's policy. Lack of these risk handling abilities make firm limit the choice for risk management strategies (Ritchie and Brindley, 2007).

Member selection
Before distributing risks to other supply chain members, any firms should remind that there is no risk preference by the others (Lietke and Toporowski, 2007). However, most members are forced by commitment and contractual agreement (Lietke and Toporowski, 2007; Shangina, 2007). Trust is another key factor influencing firm to judge whom should be assigned/ allocated for risk distribution scheme (Shangina, 2007). Trust between parties helps to raise the fulfilment of obligation and supply chain relationship.

The satisfaction level causes trust among members on the particular risk control. Lietke and Toporowski (2007) found that firm should realise the type of supply chain members, task characteristics, and situation to avoid conflict between parties. Types of supply chain members then consider the level of goal conflict, effort aversion, norms, quality of fit, strategic misrepresentative, and reputation. The task characteristics enable the firm to spread the risk to members who sound efficient and suitable signal. The firm can judge by their observation or program management and evaluating members' ability. Risk management would definitely be effective if firm gives to the right person to manage.

Supply chain risk management strategy

Manuj and Mentzer (2008b) helped to indicate 3 elements before choosing proper risk management strategies: (1) temporal focus, (2) supply chain flexibility, and (3) supply chain environment. First, temporal focus is discussed based on the short term strategies. It is required to get immediate outcomes with lower investment such as reward system or cost cutting. However, temporal focus does only reduce but not mitigate risks from firms. Second, supply chain flexibility mentioned about the firm's ability to facilitate coordinating process and help organisation to manage high level of environmental inherent. Third, supply chain environment focuses on the risks from supply and demand sides because other risks, like operational risks, are taken care by functional departments.

These supply and demand risks sound important because they are outside the control by firm. Manuj and Mentzer (2008a) developed a global supply chain risk management framework and encompassed 5 steps to mitigate risks by suggesting 7 strategies: (1) avoidance, (2) postponement, (3) speculation, (4) hedging, (5) control, (6) share/ transfer, and (7) security. The concept of risk avoidance is based on the mitigation result by altering firm practices. Two strategies under risk avoidance aim to reduce risk event to be zero or reduce the probability and likelihood to occur. Risk postponement concerns delay to suit demand optimisation by adjusting the supply to demand uncertainty. In opposite, risk speculation strategy concerns the anticipation of future demand for example firms must hold stock/inventory to prevent product shortage to customers. Risk control and risk share/transfer are considered in the same category.

They relate to vertical integration, contracts, and agreements in a pattern of forward and backward (supply and demand side). Last, risk security strategy aims to protect information flow within and outside organisation. This security system covers monitoring systems and government regulation. The goal of such risk management aims at mitigating risks (Manuj and Mentzer, 2008a) which be measured on the reduction of risk exposure (Norrman and Jansson, 2008).

Table 2 hereunder provides all critical constructs derived from the review of prior literatures with the description for each construct.

FACTORS	*CONSTRUCTS*	*DESCRIPTION*	*SOURCE*
RISK SELECTION	*RISK IDENTIFICATION*	*TO IDENTIFY ALL RISK TYPES EXISTED IN FIRM*	*GHOSHAL, 1987; ATKINSON, 2005; NG AND LOOSEMORE, 2006; MANUJ AND MENTZER, 2008B; OKE AND GOPALAKRISHNAN (2009)*
	RISK EVALUATION	*TO EVALUATE PARTICULAR RISK EXPOSURE BASED ON IMPACT AND PROBABILITY TO OCCUR*	
LACK OF RISK CONTROL ABILITY	*TECHNICAL/ PRODUCTION CAPABILITY*	*TO CONSIDER THAT THE CURRENT MACHINERY CAPACITY, PRODUCTION CAPACITY, QUALITY CONTROL, AND SUPPLY CONTINUITY NOT SUITED FOR RISK MANAGEMENT*	*LEE AND WANG, 2009; MOUSAKITIS AND ASKOUNIS, 2008; KIRBY, 2006; GUNASEKARAN, PATEL, AND MCGAUGHEY 2004*
	HUMAN RESOURCE CAPABILITY	*TO CONSIDER THAT THE CURRENT MANPOWER AND THEIR SKILL, TRAINING PROVIDED, AND RECRUITMENT CRITERIA NOT SUITED FOR RISK MANAGEMENT*	
	INFRASTRUCTURE CAPABILITY	*TO CONSIDER THAT THE CURRENT NETWORK SUPPORT, INFORMATION TRANSFER, TECHNOLOGY, AND WASTE DISPOSAL CAPABILITY NOT SUITED FOR RISK MANAGEMENT*	
	FINANCIAL CAPABILITY	*TO CONSIDER THAT THE CURRENT INVESTMENT CAPABILITY NOT SUITED FOR RISK MANAGEMENT*	
	LEADERSHIP AND STRATEGY CAPABILITY	*TO CONSIDER THAT THE CURRENT MANAGEMENT SUPPORT, INNOVATION, AND LEGAL SUPPORT ISSUE NOT SUITED FOR RISK MANAGEMENT*	
MEMBER SELECTION	*AMOUNT OF RISKS BEING DISTRIBUTED*	*TO DETERMINE AMOUNT OF RISKS FOR EACH SUPPLY CHAIN MEMBER*	*LIETKE AND TOPOROWSKI, 2007; SHANGINA, 2007*
	NUMBER OF MEMBERS	*TO DETERMINE PROPER NUMBER OF MEMBERS FOR RISKS BEING DISTRIBUTED TO*	
	BARGAINING POWER	*TO DETERMINE THE CURRENT LEVEL OF RELATIONSHIP AND CONTRACTUAL AGREEMENT BETWEEN FIRM AND EACH SUPPLY CHAIN MEMBER*	
	TRUST	*TO DETERMINE THE LEVEL OF GOAL CONFLICT OR TRUST BETWEEN FIRM AND EACH SUPPLY CHAIN MEMBER*	
	RISK HANDLING ABILITY	*TO DETERMINE THE RISK HANDLING ABILITY OF EACH SUPPLY CHAIN MEMBER*	
	EFFORT AVERSION	*TO DETERMINE THE EFFORT TO REDUCE RISK BY EACH SUPPLY CHAIN MEMBER*	
	REPUTATION	*TO DETERMINE THE EXPERIENCES AND PROFESSIONAL TECHNIQUES FOR RISK MANAGEMENT OF EACH SUPPLY CHAIN MEMBER*	
RISK MITIGATION	*RISK EVALUATION AFTER RISK MANAGEMENT*	*TO EVALUATE PARTICULAR RISK EXPOSURE BASED ON IMPACT AND PROBABILITY TO OCCUR*	*MANUJ AND MENTZER, 2008A; NORRMAN AND JANSSON, 2008*

Table 2: Summary of constructs under each variable of proposed framework

The proposed framework is derived hereunder. It considers 5 critical variables: (1) risk selection, (2) lack of risk control ability, (3) member selection, (4) risk distribution (risk management strategies), and (5) risk mitigation under 6 relationships.

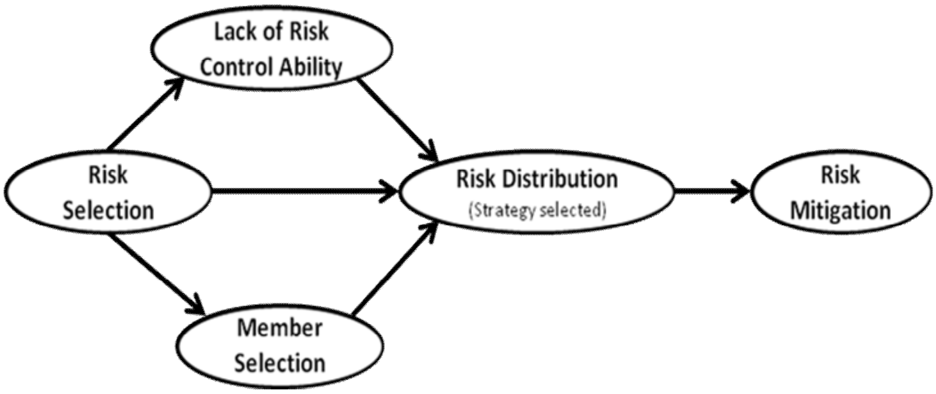

Figure 1: Proposed framework for risk distribution strategy

From figure 1, the decision making for firm to distribute risks is critically based on 3 input factors: risk selection, lack of risk control ability, and member selection. Risk distribution is similar to other risk management strategies that are able to manage effectively for particular risk types. To select high risk exposure, the proper strategies helps to reduce huge impact to firm. Risk selection is then considered as the first factor for the proposed framework. Moreover, risk selection reflects to choose members who are prompt to manage the selected risks. Since risk control characteristics are different from firm to firm, thus they are capable to control the specific type and limited amount of risks. Firm then needs to make a decision to identify proper number of firms for risks being distributed and the amount for each of them. In fact, there is no risk preference by any. To prevent conflict among organisations, firm should try to manage risks by themselves before distributing to others. However, risk distribution will be considered as an alternative strategy unless firm can control risks with their current practice. Supply chain members then play an important role for their help mitigating risks under their accountability. The collaboration among members then enables to reach the ultimate goal.

CONCLUSION

In this paper, a critical literature review has been used to develop the proposed framework of risk distribution strategy in the supply chain. Adding by the developed definition of risk distribution strategy, the critical decision factors for risk mitigation by risk distribution tactic are all identified. The framework is used for explaining how risks are distributed in the supply chain. However, the proposed framework will be further tested against case example to get preliminary feedback and finally validated with the specified industry.

REFERENCES

Anon., 1964. When the Lighter "Fades Away" Who pays?: A Problem in the Distribution of Maritime Risk. *The Yale Law Journal*, 73(4), pp. 717-726.

Atkinson, W., 2005. Risk management: a new strategy with a historic perspective. *Purchasing*, 134 (12), pp. 37-41.

Bartley, M., et al., 2000. Social Distribution of Cardiovascular Disease Risk Factors: Change among men in England 1984-1993. *Journal of Epidemiology and Community Health*, 54(11), pp. 806-814.

Calabresi, G., 1961. Some Thoughts on Risk Distribution and the Law of Torts. *The Yale Law Journal*, 70(4), pp. 499-553.

Caballero, D., Beltran, I., Velasco, A., 2007. Forest Fires and Wildland-Urban Interface in Spain: Types and Risk Distribution. *Proceeding of the IV International Wildfire Conference*. Seville, Andalucia, 13th -17th May, 2007.

Choiniere, R., Lafontaine, P., Edwards, A.C., 2000. Distribution of Cardiovascular Disease Risk Factors by Socioeconomic status among Canadian Adults. *Canadian Medical Association Journal*, 162(9), pp. S13-S14.
Coley, F.J.S., 2008. *Exploring whole system design*. Ph.D. Cranfield University.
Croom, S., Romano, P., Giannakis, M., 2000. Supply chain management: an analytical framework for critical literature review. *European Journal of Purchasing and Supply Management*, 6, pp. 67 – 83.
Dupras, L., 2007. Trading off risks to drive competitive advantage. *Supply Chain Europe*, 16(6), pp. 24-27.
Faria, J.A., Nunes, E., Matos, M.A., 2010. Cost and quality of service analysis of production systems based on the cumulative downtime. *International Journal of Production Research*, 48(6), pp. 1653-1684.
Ferguson, M., Peters, S., 1997. Cultural Affinity and Lending Discrimination: The Impact of Underwriting Errors and Credit Risk Distribution on Applicant Denial Rate. *Journal of Financial Service Research*, 11(1-2), pp. 153-168.
Ford, E.S., Giles, W.H., Mokdad, A.H., 2004. The Distribution of 10-Year Risk for Coronary Heart Disease among US Adults. *Journal of the American College of Cardiology*, 43(10), pp. 1791-1796.
Forte, A.D.M., 1987. Marine Insurance and Risk Distribution in Scotland before 1800. *Law and History Review,* 5(2), pp. 393-412.
Gao, X., et al., 2001. Applying Background Risk Distribution to Evaluate the Cost-Effectiveness of Three Preventing Drug Therapies for Osteoporotic Fractures. Value in *Health*, 4(2), pp. 69-70.
Ghoshal, S., 1987. Global strategy: An organizing framework. *Strategic Management Journal*, 8(5), pp. 425-440.
Gunasekaran, A., Patel, C., McGaughey, R.E., 2004. A framework for supply chain performance measurement. *International Journal of Production Economics*, 87, pp. 333-347.
Hallikas, J., et al. 2004. Risk Management Process in Supplier Network. *International Journal of Production Economics*, 90, pp. 47-58.
Hay, S.I., et al., 2004. The Global Distribution and Population of Risk of Malaria: Past, Present, and Future. *The Lancet Infectious Disease*, 4, pp. 327-473.
Hyatt, D.E., Pesando, J.E., 1996. The Distribution of Investment Risk in Defined Benefit Pension Plans: A Reconsideration. *Industrial Relations*, 51(1), pp. 136-157.
Ji, X., et al, 2010. Distribution of supply chain risk based on cooperative games. In: *Proceedings of the International Symposium on Intelligent Information Systems and Applications (IISA' 09)*. Qingdao, P.R. China, 28-30 October 2009.
Juttner, U., 2005. Supply Chain Risk Management: Understanding the Business Requirements from a Practitioner Perspective. *International Journal of Logistics Management*, 16(1), pp. 120-141.
Juttner, U., Peck, H., Christopher, M. 2003. Supply Chain Risk Management: Outlining an Agenda for Future Research. *International Journal of Logistics: Research & Application*, 6(4), pp. 197-210.
Kirby, S., 2006. *Purchasing operations*. The Chartered Institute of Purchasing and Supply. UK: Lincolnshire.
Lee, T.C., Lee, T.H., Wang, C.H., 2009. Decision analysis for construction contract risk-sharing. *Journal of Marine Science and Technology*, 17(2), pp. 75-87.
Li, Y., Zhao, L. 2009. Supply Chain Measurement and Transmission based on Products Pricing. *2009 International Joint Conference on Computational Sciences and Optimization*, 1, pp. 328-332.
Lietke, B., Toporowski, W., 2007. Principal-Agent Conflicts in Efficient Consumer Response. In: Proceedings of EMNet 2007, *Economics and Management of Networks: Franchising, Cooperatives, Strategic Alliances, Joint Ventures and Venture Capital Relations*. Rotterdam, Netherlands 28.-30 June 2007.
Manuj, I., Mentzer, J.T., 2008a. Global supply chain risk management. *Journal of Business Logistics*, 29(1), pp. 133-135.
Manuj, I., Mentzer, J.T., 2008b. Global supply chain risk management strategies. *International Journal of Physical Distribution and Logistics Management*, 38(3), pp. 192-223.

McMichael, A.J., 1989. Coronary Heart Disease: Interplay between Changing Concepts of Aetiology, Risk Distribution, and Social Strategies for Prevention. *Community Health Studies*, 13(1), pp. 5-13.

Mohan, U., Viswanadham, N., Trikha, P., 2009. Impact of avian influenza in the Indian poultry industry: a supply chain risk perspective. *International Journal of Logistics Systems and Management*, 5(1-2), pp. 89-105.

Mousakits, S., Askounis, D. (2008). A Capability Assessment Framework for the Adoption of B2B Integration Systems. Proceedings of the 1st world summit on The Knowledge Society: *Emerging Technologies and Information Systems for the Knowledge Society 2008*, Athens, Greece. September 24 - 26, 2008.

Ng, A., Loosemore, M., 2007. Risk Allocation in the Private Provision of Public Infrastructure. *International Journal of Project Management*, 25 (1), pp. 66-76.

Norozi, K., et al., 2006. Incident and Risk Distribution of Heart Failure in Adolescents and Adults with Congenital Heart Disease after Cardiac Surgery. The *American Journal of Cardiology*, 97(8), pp. 1238-1243.

Norrman, A., Jansson, U., 2008. Ericson's proactive supply chain risk management approach after a serious sub-supplier accident. International Journal of Physical Distribution and Logistics Management, 34(5), pp. 434-456.

Oke, A., Gopalakrishnan, M., 2009. Managing disruptions in supply chain: a case study of a retail supply chain. *International Journal of Production Economics*, 118, pp. 168-174.

Pollock, A.J., 2001. The Federal Home Loan Banks and Risk Distribution in American Housing Finance. *Housing Finance International*, 16(1), pp. 32-36.

Pujawan, N., Kurniati, N., Wessiani, N.A., 2009. Supply chain management for disaster relief operations: principles and case studies. *International Journal of Logistics Systems and Management*, 5(6), pp. 679-692.

Ritchie, B., Brindley, C., 2007. Supply chain risk management and performance: a guiding framework for future development. *International Journal of Operation and Production Management*, 27(3), pp. 303-322.

Roberts, J.F., 1978. Common Carriers and Risk Distribution: Absolute Liability for Transporting Hazardous Materials, *Kentucky Law Journal*, 67(2), pp. 441-455.

Schoenherr, T., 2009. Logistics and supply chain management applications within a global context: an overview. Journal of Business Logistics, 30(2), pp. 1-26.

Shangina, O.A., 2007. *Main factors in choice of delivery terms: a multiple case study of Japanese and Russian importers in seafood trade with Norway*. Master. University of Tromso.

Steyer, R.H., et al., 1940. Distribution on Risk Imposed Upon Corporate Officials by Federal Securities Legislation. *The Yale Law Journal*, 39(8), pp. 1421-1440.

Vassallo, A. 2009. *Managed Care IBNR Claims.* [Online] (Updated 2 February 2009) Available at: http://healthcarefinancials.wordpress.com/2009/02/02/managed-care-ibnr-claims/ [Accessed 6 November 2009].

Thun, J.H., Hoenig, D., 2009. An empirical analysis of supply chain risk management in the German automotive industry. *International Journal of Production Economics*, In Press, Corrected Proof, Available online 27 October 2009.

THE PRACTICE OF EXECUTING SUPPLY CHAIN STRATEGY AMONGST THE MAJOR PARTNERS

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ABSTRACT
Purpose:
The strategies of most companies can only be effectively executed in collaboration with other supply chain members. Although there is some research into strategy execution (Hrebiniak 2005), there is no research into combined execution of strategy by supply chain (SC) partners. This review aims to determine the best way to proceed in this little known area. It will enable future research by observations of the process of execution of strategy in Australian SCs to help configure the 'next generation' of supply chains.

Design approach
The approach is to look at what people in SC partners do in relation to strategy and how this is influenced by and influences their organisational and institutional contexts (Johnson et al 2007). Simplifying assumptions limit the complexity so that progress can be made.

Findings
The result is these research questions:
1. How can a suitable, effective supply chain strategy be recognised?
2. Given (1), what relationships and organisational and informational features are helpful in execution and how do these rank?
3. Given (2), what process will provide collaborative partner companies in a SC with the best chance of successful execution of their aims to achieve their business objectives?
4. Will a longitudinal study of supply chain partners with an emphasis on strategy practice yield insights into the process of executing their chain strategy?

Originality/ Value
Execution of supply chain strategy is a critical component to management of partners in a supply chain. It can greatly assist their customer satisfaction, cost base and revenue. The original value of this paper is to determine the theoretical underpinnings of such strategy execution and outline the research required to extend knowledge of such execution in 'next generation' SCs.

INTRODUCTION
This review is based on the view that the plethora of research on strategy formation (Mintzberg & Quinn 1991; Thompson et al. 2010) and the maturing research on strategy process (Sadler and Hines 2002, Platts & Gregory 1990) is ill served by the lack of research into strategy execution, which needs to carefully carried out into what people *do* so that the strategy is well implemented. This lack of knowledge of strategy execution applies doubly to supply chain strategy which intends to direct the future configuration and organisation of complete supply chains.

The format of the review is now given. First there is a brief summary of the formation of strategy in single business companies leading to a review of strategy 'practice' , or 'what managers do' (Johnson et al. 2007). Secondly strategy formation is extended to supply chains with the model of SC strategy adopted for the review and the motivation underpinning SC strategy. Thirdly, and in depth, the focus moves on to Strategy Execution (SE). This area encompasses SE in single companies, the limited experience of SC strategy execution, a 'practice' view of SE in supply chains, culminating in the process needed to execute SC strategy. The research questions devolve from this review and lead to the proposed methodology to answer them.

LITERATURE REVIEW: ASPECTS OF STRATEGIC PLANNING

Business strategy is an organisational process inseparable from the structure, behaviour and culture of the company (Andrews in Mintzberg & Quinn, 1991, p.45). Two important aspects are abstracted, called *formulation* and *implementation*. The principal activities of strategy formulation are

(1) Identifying opportunities and threats in the company's environment and attaching an estimate of risk to the discernible alternatives,
(2) Appraising the company's strengths and weaknesses together with the resources available, and
(3) Objectively estimating the company's capacity to take advantage of perceived market needs.

The strategic alternative which results from matching opportunity and corporate capability at an acceptable level of risk is an economic strategy. Such strategy must consider which alternatives are preferred by the chief executive and which are more attractive as service to society (adapted from Ibid).

Effective implementation (or execution) requires, firstly, an organisational structure appropriate for the efficient performance of the required tasks and made effective by information systems and relationships permitting coordination of activities. Secondly, the organisational processes of performance measurement, compensation and management development must be directed towards the kind of behaviour required by the organisation's strategic purpose. Also the role of personal leadership is very important in the accomplishment of strategy (Ibid).

From their research, Thompson *et al.* (2010) state that strategy fits when value (i.e. supply) chains of different businesses present opportunities for resource transfer and lower costs through combining the performances of related SC activities and collaboration to build stronger competitive capabilities.

Turning to the functional strategy, operations, which this paper considers because of its close relationship to supply chains, Slack and Lewis (2002) state that there are two major perspectives on operations strategy: the market perspective and the resource perspective. In the former, understanding markets, in the forms of customer needs, market positioning and competitor actions leads to obtaining the required operations performance. In the latter, company resources interact with capabilities and with processes to drive operations strategic decisions.

Research further shows that a very important emphasis which SC strategy execution must have is that of *practice*: the analysis of what people *do* during the development of strategy in organisations and SCs. Johnson *et al.*(2007) are critical of most research into business strategy because it is concerned with the systems and processes of organisations *as a whole*. Such research examines mainly (1) the link between strategic planning and performance outcomes of a firm, neglecting the detailed activities involved in such planning; and (2) research on strategic decision-making, which has migrated to cross-sectional studies providing categories of decision-making modes. Johnson *et al.* (2007) argue that these two research areas sacrifice attention to what people *actually do*. Hence there is a need to shift the research agenda from a pre-occupation with the firm and its performance to include a concern for people, the tools they use, and their practices and performance in the development of strategy. A better agenda should comprise plural levels of analysis, plurality of actors, plurality of dependent variables and plurality of theories.

EXTENDING STRATEGY FORMATION TO SUPPLY CHAINS.

Model of SC Strategy

It is difficult to state the model of supply chain (SC) strategy being used in this research because current research does not support the concept of a generic strategy for use with most SCs. Hill (2000, p 32) identifies a framework for deriving a manufacturing strategy consistent with corporate aims. Because of the coherence of operations in both manufacturing and SCs, this framework can reasonably be applied to SC strategy, although the various partners in the SC are likely to have differing corporate aims. Hill's framework notes corporate objectives and marketing strategy, asks the question 'How do products qualify and win orders in the marketplace' and then uses this information to make process and 'infrastructure' (or soft) decisions which define the manufacturing strategy. Building on this framework, Sadler and Hines (2002) produce a process of strategic planning for SCs which was successfully applied on numerous occasions to formulate, but not execute, strategic plans.

There appear to be types of SC strategy which apply to certain SCs in certain industries. For example Cox, Chicksand and Palmer (2007, p 691) state "the lean approach, to SC strategy, has been successfully adopted in a number of primarily manufacturing industries and supply chains, but it has been criticised as a general model of business strategy". Their research finds considerable problems in red meat supply chains for two reasons. In some SCs, such as beef and lamb, lean approaches have not been successful, due to adversarial behaviour between different partners in the SC. In other SCs, such as that for pig meat, lean approaches have been successful in improving the operational efficiency of the chain, but low commercial returns have resulted for many participants in the SCs. Cox *et al.*(2007) argue that SCs have to have particular demand, supply and power and leverage characteristics for lean strategies to be appropriate.

The motivation for SC strategy is caused by the fact that most businesses, such as a retail chain, depend upon many others along the SC (* supply chain always has its wider meaning of an information directed flow of products from sources to end customers, managed by a number of partner firms. Such flow requires movement of material, parts and product, and provision of service, Sadler 2007). Hence the strategies of most companies can only be executed in collaboration with other SC members.

Nevertheless, companies have sovereign, or individual, existence. Employees work for one company, not for a supply chain. Companies are used to sharing knowledge on a has-to-know basis and certainly not strategic plans, which are seen as extremely confidential guides to their future activities. Hence there is a paradox. Companies can only achieve their strategies by sharing them to enable joint execution yet they are not prepared to share their plans.

So supply chain strategy concerns the situation in which the main partners in a supply chain to craft a strategy which addresses the whole system or network. Experience shows that this does not happen very frequently (Sadler & Wilden 2008). Such a strategy must effectively capture the forward need of both the whole chain and the key players within it. At this stage we must also consider sustainability. A good supply chain must be sustainable for its people and its environment if it is to succeed in the broader situation of social responsibility and lack of harm to the natural environment (Dunphy et al (2003).

PROCESS OF SC STRATEGY EXECUTION

Initially execution of business strategy is reviewed, proceeding then to SC strategy execution.

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, synchronising the people accountable in their various disciplines, and linking rewards to outcomes (Bossidy & Charan, 2002).

Coming from a practical view in senior management, Bossidy and Charan (2002) argue that there are three core processes in execution. The first process, the People Process, aims to link strategy with operations through correct deployment of people. This process begins with the right kinds and numbers of people to execute the strategy. It then develops a pipeline of capable leaders through continuous improvement and succession depth. It is necessary to deal with non-performers, moving them to more suitable jobs. Then the Human Resources function takes on a wider role to obtain great people and train them quickly. The second process of execution, the Strategy process gives utmost attention to the 'hows' of executing the strategy. For example,

- Do you have the organisational capability to execute the plan?
- Are the short-term and the long-term balanced?
- What are the important milestones for executing the plan?
- Can you adapt the plan to rapid changes in business environment?

The third process of execution is the Operations Process. This process requires synchronisation: all the parts of the organisation, working under common assumptions, must link their priorities with other parts. An operating plan must be built, for a three year horizon, comprising setting targets, developing action planes and getting agreement from all parties. Typically trade-offs are required between the need to conserve resources and the short term or to make immediate investments which will grow the business over the long term. After the operations process is agreed, the leader sends each person a memo outlining the details of the agreements.

The main academic work on (business) strategy execution appears to be Hrebiniak's book *Making Strategy Work: Leading Effective Execution and Change* (2005):

> *Execution is critical to success. It represents a disciplined process or a logical set of connected activities that enables an organisation to take a strategy and make it work. Without a careful, planned approach to execution, strategic goals cannot be attained. Developing such a logical approach, however, represents a formidable challenge to management.* (2005, p 3)

Hrebiniak shows why execution is even more important than many senior executives realise and sheds new light on why businesses fails to deliver on even their most promising studies. He carried out some surveys in USA (Hrebiniak, 2005) which generated a list of obstacles which prevent strategy execution. Table 1 shows the eight most important obstacles, according to these surveys. Survey 1 was a sample of 243 managers involved strategy formulation and execution. Survey 2 is a sample or 200 managers attending an executive program on strategy implementation.

	Obstacles	Survey 1	Survey 2
1	Inability to manage change effectively or to overcome internal resistance to change	1	1
2	Trying to execute a strategy that conflicts with the existing power structure	2	5
3	Poor or inadequate information sharing between individuals or business units responsible for strategy execution	2	4
4	Unclear communication of responsibility and/or accountability for execution decisions or actions	4	5
5	Poor or vague strategy	5	2
6	Lack of feelings of 'ownership' of a strategy or execution plans among key employees	5	8
7	Not having guidelines or a model to guide strategy-execution efforts	7	2
8	Lack of understanding of the role of organisational structure and design in the execution process	9	5

Table 1 Obstacles to Strategy Execution

My view of execution process, from the literature, corresponds to Hrebiniak's 'logical approach'. Building on Hrebiniak's work, his model of strategy execution is reproduced with 'Supply chain strategy' taking the place of 'Corporate Strategy' in Figure 1 (ibid p 35). With the strategy of collective companies partnered in the SC taking the place of Hrebiniak's 'corporate strategy' ellipse, the amended model comprises 'supply chain strategy' driving 'business strategy and operating objectives' for those partners. This in turn drives 'incentives and controls'. In practice the business strategy of the partners will also drive chain strategy (Sadler & Wilden, 2008).

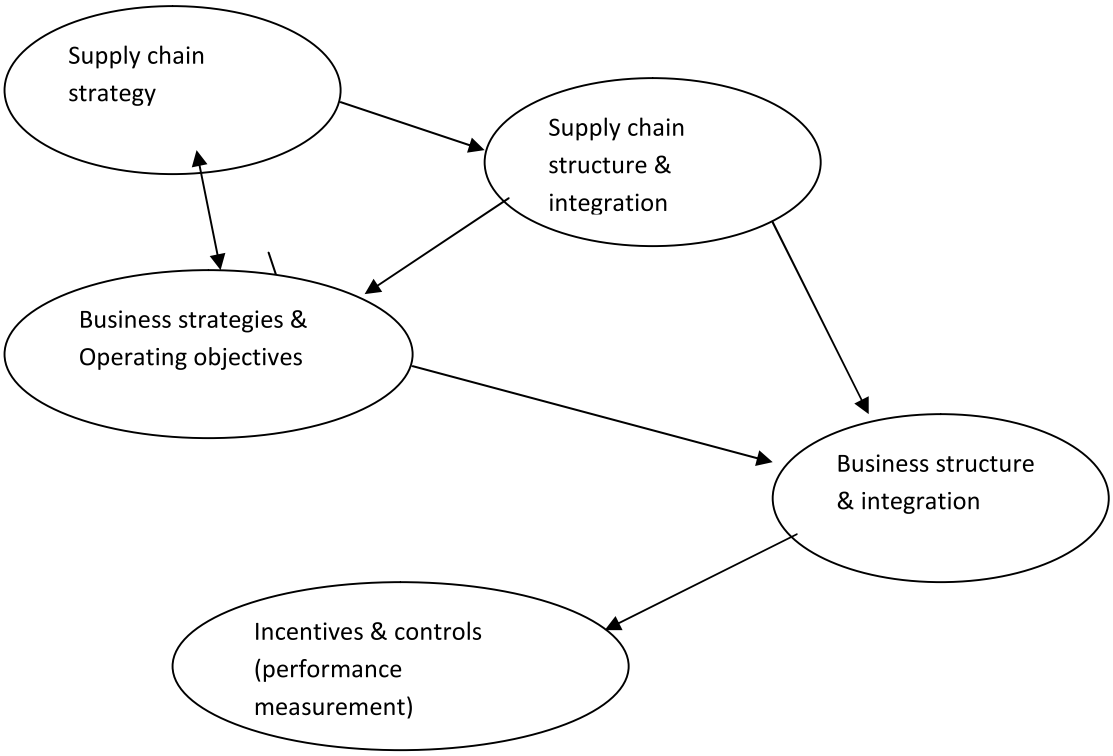

Figure 1 Executing supply chain strategy (After Hrebiniak, 2005)

The research by Hrebiniak is the only academic study my literature review found on the process of execution of business strategy even though it a crucial step. Only through effective implementation will the gains envisaged in the strategy be obtained. Implementation does not appear to have been studied in the area of supply chain strategy. A review of the past five years of the International Journal of Operations and Production Management did not reveal any work of this nature (Sadler & Manzoni, 2006). Search in the Emerald/ Ebscohost database showed many studies which mention execution or implementation without developing the topic. Because of the economic importance of execution, theory needs to be developed in this gap in knowledge.

Because so little is known about the implementation of SC strategy, any research has the potential to improve our knowledge of this important area of knowledge.

The effectiveness of execution of a superior supply chain strategy is heavily influenced by the relationships in the chain (Christopher and Lee, 2004). The organisational features such as ability to communicate effectively and the exercise of authority are important to strategy execution. Thirdly, the availability and sharing of information, so that decision-makers throughout the chain have as much accurate information as possible on which to base their determinations (Power 2005).

It is argued that, with good strategy and good relationships throughout the chain, it is still possible for execution to be mediocre. The main evidence for this comes from observation of formation of supply chain strategy (Sadler and Hines, 2002). The next section therefore draws on process to improve execution (Sadler and Wilding, 2008). Some of the techniques of project management (Turner, 2009) can be used, but it is argued that execution of chain strategy is more profound and more complex than most projects, particularly in its human interactions.

FINDINGS INCLUDING RESEARCH QUESTIONS

According to the literature, the driving forces for better execution of SC strategy appear to lie in a combination of the following three reasons:

I. A strong desire to have a more effective supply chain, to serve customers and generate more profit,
II. Growing trust amongst companies, who work together over a period of time, like what they experience, share data and become prepared to share strategic plans and implement them together, and
III. It could be that some companies are pushed into closer collaboration because of the difficult circumstances in their industry: Loss of market or inability to match global competitors.

Hrebiniak (2005) says planning and execution are interdependent: it is essential to study planning in a chain before watching execution. Hence research must study, or watch, strategic plan formation before tracking the ensuing plan execution. Power (2005) says there is interdependence between integration (technologies, logistics and partnerships), a strategic view of supply chain systems and an implementation approach. All three need to inform and underpin each other to obtain benefits for all partners.

Can Hrebiniak's 'Execution Challenge' (2005, p. 22) be extended to apply to supply chain companies? This table seeks to employ Hrebiniak's areas in a supply chain context.

Areas of opportunity	Supply chain challenge
1. Developing a model to guide execution decisions or actions	Model extended to all main players in supply chain
2. Understanding how the creation of strategy affects the execution of strategy	Watch plan formation in a supply chain before studying its execution
3. Manage change effectively, including culture change	Close collaboration enables change to be managed throughout the chain and common culture developed
4. Understanding power or influence and using it for execution success	Understanding the powerful players in the supply chain and using them to promote effective chain-wide strategy execution
5. Developing organisational structures that foster information sharing, coordination and clear accountability	Developing chain-wide structures that foster these same aims throughout the supply chain
6. Developing effective controls and feedback mechanisms	Developing effective performance measures along the whole supply chain
7. Knowing how to create an execution-supportive culture	Creating an execution-supportive culture across all members of the supply chain
8. Exercising execution- biased leadership	Putting sovereignty aside and allowing supply chain leadership to promote execution actions

Table 2 Execution Challenges extended to SC partners

Hence the research questions which will be used to derive knowledge in the execution of supply chain strategy are:

1. How can a suitable, effective supply chain strategy be recognised?
2. Given a suitable supply chain strategy, what relationships and organisational and informational features are helpful in execution and how do these rank in terms of necessity?
3. Given a good supply chain strategy and the necessary precursors (see 2), what process will provide collaborative partner companies in a supply chain with the best chance of successful execution of their aims to achieve their business objectives?
4. Will a longitudinal study of supply chain partners with an emphasis on strategy practice yield insights into the process of executing their chain strategy?

RESEARCH METHOD PROPOSED

To address this lack of knowledge of SC strategy execution, I propose to evaluate the success of implementing sound operations and supply chain strategies by the integration of social, technical and information systems in the focal company and its main partners. Such research will employ interviews and action research methodology involving researchers as participant-observers (Karlsson, 2009).

The steps required are believed to be:

- Assess the completeness and soundness of the value chain strategy to judge its suitability for this research. If necessary, lead the value chain team in a strategic SC planning process to generate a superior plan for them to implement.
- Interview senior and middle managers, with an emphasis on purchasing, logistics and operations managers.
- Watch people implement the various actions in that plan
- Provide advice only on the *process* of implementation
- Conduct study visits over a considerable period to assess and record the actions taken by managers accountable for policy implementation, giving a sufficient period for many strategic actions to be executed. Each visit aims to record progress on the implementation of strategy as specified on the action plan by collecting formal data from the information system, action reports and documents. Execution of actions will be recorded under headings of technology, people or information.
- Allow for outside factors which affect the necessity for any particular strategy to be executed

REFERENCES

Bossidy L & Charan R, 2002, *Execution: the Discipline of getting things done*, Random House, London, UK.

Christopher M, Lee H, (2004) 'Mitigating supply chain risk through improved confidence', *I.J. Physical Distribution and Logistics Management*, Vol. 34 No. 5, pp 388-96.

Hrebiniak LG, 2005, *Making Strategy work: leading effective execution and change,* Wharton, NJ, USA.

Johnson G, Langley A, Melin L and Whittington R (2007) *Strategy as Practice: Research Directions and Resources*, Cambridge UP, UK.

Karlsson C (ed.), 2009, *Researching Operations Management*, Routledge, New York, USA.

Mintzberg H, Quinn JB, 1991, *The Strategy Process*: *Concepts, Contexts, Cases*, 2nd edn, Prentice Hall, New Jersey, USA.

Platts KW & Gregory MJ, 1990, 'Manufacturing Audit in the Process of Strategy Formulation', *I.J. of Operations and Production Management*, Vol. 10 No.9, pp 6-26.

Power D, 2005, 'Supply Chain Management integration and implementation: a literature review', *Supply Chain Management: an International Journal*, 10:4, p 252-63.

Sadler I, 2007, *Logistics and Supply Chain Integration*, Sage, London, UK.

Sadler I, Hines P, 2002, 'Strategic operations planning process for manufacturers with a supply chain focus: concepts and a meat processing application' *Supply Chain Management: An International Journal,* Vol.7 No. 4, p 225-241.

Sadler I, Manzoni A, 2006, 'Implementation of Operations and Logistics Strategy in the food processing industry: a critical review', in Proc. Of 11th IS on Logistics, Pawar KS, Yu M, Zhao X and Lalwani CS, Eds., Beijing, China.

Sadler I, Wilden D, 2008, 'The process of execution of supply chain functional strategy: a review of knowledge of content and process', Proc. of 13th International Symposium of Logistics, Bangkok, Thailand.

Skinner W, 1992, 'Missing the links in manufacturing strategy' in 'Manufacturing Strategy: Process and Content', Ed. C.A. Voss, Chapman and Hall, p.22-25.

Slack N, Lewis M, 2002, *Operations Strategy*, Prentice Hall, Harlow, UK.

Thompson AA, Strickland AJ & Gamble JE, 2010, *Crafting and Executing Strategy*, 17th edn., McGraw-Hill, Boston, USA.

Turner, JR, 2009, *The Handbook of Project Management: Leading Strategic Change in Organisations*, Mc Graw Hill, New York, USA.

THE INFLUENCES OF DEMAND UNCERTAINTY ON THE RELATIONSHIP BETWEEN SUPPLY CHAIN INTEGRATION AND DELIVERY PERFORMANCE

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ABSTRACT
Previous studies suggest that supply chain integration could improve delivery performance but its performance implication could be impaired by demand uncertainty. Based on a survey questionnaire with 151 firms from Thai automotive industry, hierarchical regression models are used to test the moderating effects of demand uncertainty. Results suggest that demand uncertainty had significantly and negatively moderated the relationship between supplier/internal integration and delivery performance. This paper contributes to the development of a contingency theory of supply chain integration.

INTRODUCTION
Supply chain integration may improve delivery performance (Stank *et al.*, 1999; Iyer *et al.*, 2004; Germain and Iyer, 2006). Further empirical studies concluded that different dimensions of supply chain integration, e.g., internal integration, supplier integration, and customer integration, could contribute to delivery performance (Morash *et al.*, 1996; Fawcett *et al.*, 1997; Daugherty *et al.*, 1999; Stank *et al.*, 2001). However, this paper posits that the impact of supply chain integration on delivery performance is not unconditional; instead, it is contingent on demand uncertainty. We aim to contribute to the logistics and supply chain management literature by clarifying such moderating effects. The findings further provide practical guidance to logistics and supply chain managers on the effective implementation of supply chain integration under demand uncertainty.

THEORETICAL DEVELOPMENT
Our focus here is to develop hypotheses which posit the impacts of internal, supplier and customer integration on delivery performance. The delivery performance of a logistics system can be measured in terms of on-time delivery, delivery lead-time, and delivery reliability (Fawcett *et al.*, 1991; Nobel, 1997). The logistics and supply chain literature in general explains the positive impact of supply chain integration on delivery performance by referring to the sharing of reliable and real-time data both within and across firms in a supply chain (Daugherty *et al.*, 1999; Stank *et al.*, 1999; Sohal *et al.*, 2001; Frochlich, 2002). As explained by Flynn *et al.* (2010), internal integration breaks down functional barriers and engenders cooperation, which forms the basis for the coordination of information flow across functions. Given the importance of internal integration, Birou *et al.* (1998) found positive impacts of the linkage across functional areas on both delivery reliability and speed. The survey study by Fawcett *et al.* (1997) indicated that a failure to adopt integration between operation and logistic functions can lead to poor performance on delivery capability. Furthermore, the product development literature found that internal integration is required to achieve desirable time-to-market and cycle time performance (Dröge *et al.*, 2004). Thus, a firm with a high level of internal integration will be able to ensure on-time delivery (Sabath, 1995). Thus,

H1a: Internal integration will be positively associated with delivery performance.

Supplier integration requires alignment, information sharing, interactions between firms and their suppliers (Ragatz *et al.*, 2002). With supplier integration, it is more likely to enable frequent deliveries in small lots, use single or dual sources of supply, evaluate alternative supply sources based on quality and delivery instead of price, and establish long-term contracts with suppliers to improve delivery performance (Handfield, 1993). Likewise, Li *et al.* (2003) reported that direct supplier development and supplier's strategic objective alignment have proven to be significant predictors of purchasing performance in terms of on-time delivery and quality performance. Strategic long-term relationship can have a positive impact on the delivery capability (Choi and Hartley, 1996; Narasimhan and Carter, 1998; Carr and Pearson, 1999). Thus,

H1b: Supplier integration will be positively associated with delivery performance.

Customer integration is arguably essential to improve delivery performance (Stank *et al.*, 2001). Morash *et al.* (1996) suggest that demand-oriented logistics capabilities such as delivery speed, delivery reliability, and responsiveness to target market could reflect the closeness to customers. Firms adopt different information technology tools to share information with their customers so that they are able to implement various collaborative initiatives to capture the actual customer demand and understand the variations of customer demand (Daugherty *et al.*, 1999). Furthermore, the reduction of the variation of customer demand by sharing accurate and timely information with customers can improve delivery performance (Johnson and Scudder, 1999; Cachon, 1999). Thus,

H1c: Customer integration will be positively associated with delivery performance.

Next we examine the influence of demand uncertainty on the above three relationships. Demand uncertainty is the extent of change and unpredictability of a customer's needs and demands (Zhang *et al.*, 2002). Demand uncertainty can be viewed as the difference between the actual end-marketplace demand and the orders placed with an organization by its customers (Geary *et al.,* 2002). Typically, products with a high level of demand variability, irregular purchase, high rate of innovation and short product life-cycle will generate a higher level of demand uncertainty to the upstream suppliers (Chang *et al.*, 2002). Thus, very often customers may suddenly place an order twice the typical order-size, indirectly leading to poor delivery performance.

Some literature suggest that demand (or environmental) uncertainty should be considered as an antecedent of supply chain integration (Ragatz *et al.*, 2002) but we consider it as an exogenous factor or a moderator (O'Leary-Kelly and Flores, 2002; Fynes *et al.*, 2004). With regards to the moderating effect of demand uncertainty, there are two streams of literature. The first stream of literature is in favour of a positive moderating effect. The main argument is that uncertainty in demand will often lead to distortion of demand information (Lee *et al.*, 1997) subsequently increase the need for a firm to alter supply plans, manufacturing plans and marketing/sales plans (O'Leary-Kelly and Flores, 2002). Ideally information sharing and collaboration will enhance the ability to alter such plans and the ability to react more accurately to changing demand or supply (Flynn *et al.*, 2010). This means an integrated supply chain with a higher level of information sharing, objective alignment, and collaboration will be able to maintain on-time delivery and quick response to customer orders even when there is a high level of demand uncertainty. The second stream of the literature suggests otherwise based on the argument that, there will be more opportunity to meet delivery requirements when there is a stable demand (Fisher, 1997). This is especially valid for supply chains operating in a just-in-time (JIT) and continuous replenishment environment (Schonberger, 1986; Zipkin, 1991). Due to the sharing of real-time information and the ability to work collaboratively, firms in an integrated supply chain will be able to enhance the accuracy of production planning and inventory allocation in an environment with a lower level of demand uncertainty. This implies that firms operating in a just-in-time environment will have a better delivery performance under a low, but not a high level of demand uncertainty. We thus have developed the following hypotheses:

H2: Demand uncertainty will moderate the association (a) between internal integration and delivery performance, (b) the association between supplier integration and delivery performance, and (c) the association customer integration and delivery performance.

RESEARCH METHODOLOGY

Data for this study were collected via a questionnaire survey of Thai automotive industry. Responses were obtained from mainly purchasing managers, CEOs, presidents, vice presidents, and directors because they have detailed knowledge of supply chain integration practices and performance. 151 completed and usable responses, with a response rate of 20.85%, were collected. The measures of supply chain integration constructs (internal integration, supplier integration and customer integration), demand uncertainty, and delivery performance were adapted from existing scales found in the previous studies. A five-point Likert scale ranging from "strongly disagree" to "strongly agree" was used in this study.

Non-response bias was tested by applying t-tests to compare demographic variables between the first and second waves of responses. The t-test results indicated no significant difference in any criterion, with significance levels below 0.1, suggesting no non-response bias. Furthermore, the risk of common method variance was also tested using the Harman one-factor test (Kotabe *et al.*, 2003). No single factor was apparent in the un-rotated factor structure. This indicates that there is no problem with common method variance. The validity and reliability of the variables are assessed as follows (details not included due to the lack of space). The Cronbach's alpha values (ranging from 0.79 to 0.90) and composite reliability (ranging from 0.83 to 0.93) for all variables were well above the critical values, suggesting acceptable psychometric properties. The comparative fit index (CFI) values, varied from 0.96 to 0.99 (above 0.9), and the standardized root mean square residual (SRMR) values, varied from 0.02 to 0.04 (below 0.08), suggesting all the constructs were unidimensional (Hu and Bentler, 1999). Furthermore, the incremental fit index (IFI), ranged from 0.94 to 0.99, and the Tucker-Lewisi index (TLI), ranged from 0.90 to 0.99, were also well above the recommended threshold of 0.90 (Hu and Bentler, 1999). To conclude, all the measurement models had acceptable fit indices, thus proving the satisfactory fit between the data and the proposed measurement models for supply chain integration constructs, demand uncertainty, and delivery performance. Furthermore, discriminant validity, measured by CFA, found that all three Chi-square differences between the fixed and free solutions in Chi-square were statistically significant ($p<0.01$), confirming the discriminant validity for all variables.

RESULTS

Hierarchical regression analysis was used to test all hypotheses. The regression results summarised in Table 1 (initial model) indicate that both internal integration and supplier integration were positively and significantly associated with delivery performance. Hypotheses H1a and H1b are supported. However, hypothesis H1c is not supported.

Table 1 Hierarchical regression analysis

Independent variables	Dependent variable: delivery performance			
	Initial model	DU added	Interactions added	
Plant size	0.071			
Internal integration (II)	0.293**		II x DU	-0.484**
Supplier integration (SI)	0.250**		SI X DU	-0.352**
Customer integration (CI)	0.122		CU x DU	-0.130
Demand uncertainty (DU)	Not included	-0.201**		
Change in R^2	0.239	0.050		0.146
Change in F	14.97**	9.89**		3.75**

*Note: *p < 0.1; **p < 0.01; ***p < 0.001*

To test hypothesis H2, we added demand uncertainty as a moderator variable (DU added), and subsequently the interactions between demand uncertainty and each of the three dimensions of supply chain integration (Interactions added) into the regression model. This method enables us to analyze the proportion of variance that is shared exclusively with each additional variable (Licht, 2003). Prior to creation of the interaction terms, both independent and moderator variables were mean-centred to reduce the potential problem of multicollinearity (Aiken and West, 1991). The variance inflation factors (VIF) associated with each regression coefficient range less than 5, suggesting no multicollinearity.

Adding demand uncertainty into the model yielded a significant change in R^2 in the regression model. As indicated by changes in R^2, adding the interactions between demand uncertainty and the three dimensions of supply chain integration further increased the predictive power of the regression model. The results show that demand uncertainty had a significant but negative moderating effect on the relationship between internal integration and delivery performance, supporting hypothesis H3a. Similarly, there is a significant but negative moderating effect of demand uncertainty on the relationship between supplier integration and delivery performance. Thus, hypothesis H3b is supported. However, hypothesis H3c is not supported, suggesting no moderating effect of demand uncertainty on the relationship between customer integration and delivery performance.

DISCUSSION & IMPLICATIONS

The significant and positive relationships between internal and supplier integration and delivery performance found in this study are congruence with most previous findings. Though previous studies suggest the positive impact of customer integration on delivery performance (Sabath, 1995; Morash, 2001; Gimenez and Ventura, 2005), our result surprisingly suggests otherwise. Our explanation for this result is that firms in the automotive firms may have implemented customer integration, not from the pressure to increase their delivery performance, but to improve other performance outcomes such as innovation and marketing (Koufteros *et al.*, 2005). Concluding a similar a result, Swink *et al.* (2007) suggest that customer integration may have an indirect impact on operational performance. Similar explanation has been put forward in another recent study (Germain and Iyer, 2006).

In terms of the two streams of literature, our results suggest that demand uncertainty had a negative moderating effect on the relationship between internal integration and delivery performance, as well as the relationship between supplier integration and delivery performance. This means that the positive impacts of internal and supplier integration were reduced when the demand uncertainty was higher. Though we found a moderating effect of demand uncertainty, the direction of the moderating effect we found is the opposite with the results of Fynes *et al.* (2004). Ideally information sharing and collaboration across functions and with suppliers will enhance the ability of a supply chain to alter manufacturing and marketing/sales plans to react more accurately to changing demand or supply (O'Leary-Kelly and Flores, 2002). However, our results suggest that internal integration and supplier integration will become more effective when demand uncertainty is low. The main difference between our study and Fynes *et al.*'s (2004) is that our study is based on samples from the Thai automotive industry and their study is based on the electronics sector in Northern Ireland. Our explanation lies in the essential of stability for the automotive supply chains in Thailand in a just-in-time (JIT) and continuous replenishment environment (Schonberger, 1986; Zipkin, 1991).

The above results have significant implications for supply chain research. The first contribution lies in the examination of three dimensions of supply chain integration as opposed to a single supply chain construct. Our results suggest that the supply chain research community should not automatically assume significant and positive relationships between supply chain integration and delivery performance. As pointed out by some previous studies (Swink *et al.*, 2007), our results further confirm that not customer integration could not have a direct positive effect on delivery performance.

The second contribution of this study lies on the clarification of the effects of different dimensions of supply chain integration on delivery performance under varying demand uncertainty. Contradictory to the conventional wisdom and prior studies (e.g., Fynes *et al.*, 2004), our results indicate that investment in a higher level of supply chain integration under a higher level of demand uncertainty will not always improve delivery performance. Logistics managers need to know which dimensions of supply chain integration to emphasized under different levels of demand uncertainty. Especially for a supply chain operating in a just-in-time environment, internal integration will have a more significant (and positive) impact on delivery performance under low, but not high levels of demand uncertainty. Similarly, supplier integration will have a more significant impact on delivery performance when there is a low level of demand uncertainty. These results further provide evidences to the establishment of a contingency theory of supply chain integration (Flynn *et al.*, 2010).

CONCLUSION

This study suggests demand uncertainty as an exogenous factor or moderator which negatively moderated the relationships between internal/supplier integration and delivery performance. The results are valuable in contributing to the development of a contingency theory of supply chain integration, which rejects the conventional view of the unconditional performance implication of supply chain integration (Fawcett and Closs, 1993). However, there is a need to overcome some limitations in the future research. First, a single respondent in a firm was asked to respond to a survey. But, in reality, no person in a firm is in charge of the entire supply chain. Second, the conceptual framework may require more contextual dimensions instead of just technological and demand uncertainties. Adding more contextual factors such as industry complexity, globalization and demand trends, product life cycle, and organizational structure would probably explain more variance and their inclusion here would be prudent. Next, the implementation of supply chain integration is a long process and therefore it might require several stages. Within different stages and business objectives, the benefits and requirements for supply chain integration implementation may vary. Thus, a longitudinal research design is needed for future studies to truly understand causal relationships between supply chain integration and delivery performance alongside the effect of other contextual factors.

REFERENCES

Aiken, L.S. and West, S.G. (1991), Multiple regression: Testing and interpreting interactions, Sage Publication, Newbury Park, CA.

Birou, L.M., Fawcett, S.E. and Magnan, G.M. (1998) "The product life cycle: a tool for functional strategic alignment", International Journal of Purchasing and Materials Management, 34(2), 37-51.

Cachon, G.P. (1999) "Managing supply chain demand variability with scheduled ordering policies", Management Science, 45(6), 843-856.

Carr, A.S. and Pearson, J.N. (1999), "Strategically managed buyer-supplier relationships and performance outcomes", Journal of Operations Management, 17(5), 497-519.

Chang, S.C., Lin, N. and Sheu, C. (2002) "Alignment manufacturing flexibility with environmental uncertainty: evidence from high-technology component manufacturers in Taiwan", International Journal of Productions Research, 40(18), 4765-4780.

Choi, T.Y. and Hartley, J.L. (1996) "An exploration of supplier selection practices across the supply chain", Journal of Operations Management, 14, 333-343.

Daugherty, P.J., Myers, M.B. and Autry, C.W. (1999) "Automatic replenishment programs: an empirical examination", Journal of Business Logistics, 20(2), 63-82.

Dröge, C., Jayaram, J. and Vickery, S.K., (2004) "The effects of internal versus external integration practices on time-based performance and overall firm performance", Journal of Operations Management, 22, 557-573.

Fawcett, S.E., Calatone, R., and Smith, S.R., (1997) "Delivery capability and firm performance in international operations", International Journal of Production Economics, 51, 191-204.

Fawcett, S.E., and Closs, D.J. (1993) "Coordinated global manufacturing, the logistics manufacturing interaction and firm performance," Journal of Business Logistics, 14(1), 1-25.

Fisher, M.L. (1997) "What is the right supply chain for your product?" Harvard Business Review, March/April, 105-116.

Flynn, B.B., Huo, B., Zhao, X., (2010) "The impact of supply chain integration on performance: a contingency and configuration approach", Journal of Operations Management, 28, 58-71.

Fornell, C. and Larcker, F. (1981) "Evaluating structural equation models with unobservable and measurement error", Journal of Marketing Research, 18(1), 39-50.

Frohlich, M.T. (2002) "e-integration in the supply chain: Barriers and performance", Decision Science, 33(4), 537-555.
Frohlich, M.T. and Westbrook, R., (2001) "Arcs of integration: an international study of supply chain strategies", Journal of Operations Management, 19, 185-200.
Fynes, B., de Búrca, S. and Marshall, D., (2004) "Environmental uncertainty, supply chain relationship quality and performance," Journal of Purchasing and Supply Management, 10(4/5), 179-190.
Geary, S., Childerhouse, P. and Towill, D. (2002) "Uncertainty and the seamless supply chain", Supply Chain Management Review, July/August, 52-61.
Germain, R. and Iyer K.N.S. (2006) "The interaction of internal and downstream integration and its association with performance", Journal of Business Logistics, 27(2), 29-52.
Gimenez, C. and Ventura, E. (2005) "Logistics-production, logistics-marketing and external integration: their impact on performance", International Journal of Operations & Production Management, 25(1), 20-38.
Handfield, R.B. (1993) "A resource dependence perspective of just-in-time purchasing", Journal of Operations Management, Vol. 11, pp. 289-311.
Hu, L., and Bentler, P.M., (1999) "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives", Structural Equation Modeling, 6, 1-55.
Iyer, K.N.S., Germain, R., and Frankwick, G.L., (2004) "Supply chain B2B e-commerce and time-based delivery performance," International Journal of Physical Distribution & Logistics Management, 34 (7/8), 645-661.
Johnson, M.E. and Scudder, G. (1999) "Supporting quick response through scheduling of make-to-stock production/inventory systems", Decision Science, 30(2), 441-459.
Koufteros, X.A., Vonderembse, M., and Jayaram, J., (2005) "Internal and external integration for product development: the contingency effects of uncertainty, equivocality, and platform strategy", Decision Sciences, 36(1), 97-133.
Lee, H.L., Padmanabham, V. and Whang, S., (1997) "The bullwhip effect in supply chains", Sloan Management Review, 38(3), 93-102.
Li, S. (2002) An integrated model for supply chain management practices, performance and competitive advantage, Unpublished Doctoral Dissertation, University of Toledo, Toledo, OH.
Li, L., Humphreys, P., Chan, L.Y., & Kumaraswamy, M. (2003) "Predicting purchasing performance: the role of supplier development programs", Journal of Material Processing Technology, 66(3/4), 1-7.
Liao, K., and Tu, Q., (2008) "Leveraging automation and integration to improve manufacturing performance under uncertainty", Journal of Manufacturing Technology Management, 19(1), 38-51.
Morash, E.A. (2001) "Supply chain strategies, capabilities, and performance", Transportation Journal, Fall, 37-54.
Morash, E.A., Dröge, C. and Vickery, S. (1996) "Strategic logistics capabilities for competitive advantage and firm success", Journal of Business Logistics, 17(1), 1-22.
Morash, E.A., Dröge, C. and Vickery, S. (1997) "Boundary-spanning interfaces between logistics, production, marketing and new product development", International Journal of Physical Distribution and Logistics Management, 27(5/6), 350-369.
Narasimhan, R. and Carter, J.R. (1998) "Liking business unit and material sourcing strategies", Journal of Business Logistics, 19(2), 155-171.
Noble, M.A. (1997) "Manufacturing competitive priorities and productivity: an empirical study" International Journal of Operations and Production Management, 17(1), 85-99.
O'Leary-Kelly, S.W.O., Flores, B.E., (2002) "The integration of manufacturing and marketing/sales decisions: impact on organizational performance", Journal of Operations Management, 20, 221-240.
Ragatz, G.L., Handfield, R.B. and Peterson, K.J., (2002) "Benefits associated with supplier integration into new product development under conditions of technology uncertainty", Journal of Business Research, 55, 389-400.
Sabath, R., (1995) "Volatile demand calls for quick response: the integrated supply chain", Logistics Information Management, 8(2), 49-52.
Schonberger, R.J., (1986) World class manufacturing, Free Press, New York.

Sohal, A., Terziovski, M., Power, D. and Ahmad, A. (2001) Integrated supply chain management: a comparison of experiences amongst Australian and Malaysian companies, Working Paper, Monash University, Melbourne, Australia.
Stank, T.P., Keller, S., and Daugherty, P.J. (2001) "Supply chain collaboration & logistical service performance", Journal of Business Logistics, 22(1), 29-48.
Stank, T.P., Crum, M. and Arango, M., (1999) "Benefits of interfirm coordination in food industry supply chain", Journal of Business Logistics, 20(2), 21-41.
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, 148-164.
Zhang, Q., Vonderembse, M.A., Lim, J., (2002) "Value chain flexibility: a dichotomy of competence and capability", International Journal of Operations Research, 40(3), 561-583.
Zipkin, P.H., (1991) "Does manufacturing need a JIT revolution?" Harvard Business Review, 69(1), 40-50.

NATIONAL CULTURAL DIVERSITY AND GLOBAL SUPPLY CHAIN MANAGEMENT

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ABSTRACT

Purpose: In an era of global supply chains, the vast majority of supply chain theory is bound up within the North American and European business contexts. To investigate its generic applicability within a global context, this study investigates how national culture affects the uptake of supply chain management theory in practise.

Methodology: Hoefstede's (1980) well-known measures of international work-related values are used to compare the behaviours of a cross-national sample of supply chain managers. The exploratory research involves an anthropological approach of observing supply chain management behaviour within its natural setting.

Research Implications: Supply chain management concepts need to be adapted to cater for managers' cultural diversity. Identifying the most desirable supply chain improvement destination requires understanding of national, organisational and individual cultural norms. In particular, the pathway to change and the desirable leadership role must be matched to the demands of the local cultural environment.

Research Limitations: A limited number of national settings, and cases from each national setting, are investigated. Hence there is significant scope for further exploratory, intra-country and inter-country research into national cultural diversity and global supply chain management.

Original contribution: The general uptake of supply chain management in practise is slow and rather disappointing, particularly given some twenty-plus years of academic research. Although supply chain management concepts seem to be geographically generic in application, the setting directly affects the approaches undertaken in practise. The cultural values in Asian versus Anglo-Saxon working environments significantly affect supply chain management practise.

Key Words: Global supply chain comparisons, national culture, anthropology

INTRODUCTION

From a particularistic perspective the context and culture should be considered when managing operations (Prasad and Babbar, 2000). In response to direct calls for further research into supply chain culture (Zhao et al., 2008) the aim of the present study was to investigate possible affects of national culture on supply chain management (SCM) practise. Although many supply chain networks extend internationally, little research has discussed the need to tailor SCM approaches to suit the local business settings. Alternatively, can generic approaches to management and leadership be applied internationally? An all too common ethnocentric perspective results in viewing other cultures through one's own cultural lens. Hence, often overlooked are the underlying cultural factors that make one supply chain solution optimal in one country but almost infeasible in another (see for example; Aelera, 2004; Metters et al, 2010; Davies, 2006; Helmreich and Merritt, 1998; Wang, 2006; Ong, 1987).

Consider how national setting and SCM interrelate. Is there a need to tailor SCM approaches for these alternate international settings? Is supply chain theory truly generalisable, as some would have us believe (Friedman, 2006; Hoecklin, 1995)? The vast majority of research in this area has been based on the observation of supply chain practises internationally, followed by cross-comparisons of performance (for example, Childerhouse et al, 2010; Naor et al, 2010). There are however a number of shortcomings to this typical positivist approach since the context of each nation makes for unfair comparisons due to, among others: market conditions, national culture and infrastructure development that arguably can be larger influencing factors on performance than the supply chain practises themselves. In this research the national culture effects on supply chain management are investigated as this provides one of the most powerful counter-arguments to the universalism movement (out of the USA, in particular). The research questions are:

Does the behaviour of supply chain managers differ internationally?
What effect does national culture have on the way supply chains are managed?

Following is a brief review of literature on the international setting of supply chains and national culture; both from a management and a leadership perspective. The method section then provides justification for the research design. The analysis that follows is focused on the behaviour of supply chain managers and how this relates to national culture. The discussion highlights the most salient messages derived from the data and proposes further avenues of research. The paper ends with a short conclusions section.

LITERATURE REVIEW

Supply chain international comparison studies are rare and predominantly quantitative in nature. For example, Closs and Mollenkopf (2004) investigated the supply chain competency/performance relationship in North American firms and compared findings with a sample of Australian and New Zealand firms. The qualitative study by Halldorsson et al. (2008) examined SCM definitions, facilitators, and barriers to implementation, and compared data derived from North American and Scandinavian samples.

The present study was primarily conducted in three national settings: New Zealand, Thailand, and the United Kingdom. Publications in the field of SCM within the New Zealand context are very limited (Mollenkopf and Dapiran, 2005). Those few available publications highlight however that a gap exists between theory and current best practise. Wilson and Sankaran (2001), for example, identified that New Zealand's local manufacturers are lagging behind their overseas counterparts in many key areas of supply chain management. Basnet et al. (2003; 2006) recently supported these findings by highlighting that the latest theoretical supply chain developments are poorly understood and reported an equally disappointing uptake by New Zealand firms. Similarly, Böhme et al. (2008) report poor supplier relationship management practises by many New Zealand firms that result in weak linkages with key suppliers.

In Thailand SCM is still in its infant stages; particularly the small and medium enterprises and family-owned businesses. SCM practises have been widely implemented between multinational firms operating in the country but these have not yet reached the small and medium sized local suppliers (Wong and Boon-itt, 2008). Supply chain performance for most local firms is weak, with strong potential for improvement as most business owners do not yet have a grasp of supply chain issues. During a supply chain assessment of many local firms, it was discovered that tools such as the SCOR model or the Enkawa Supply Chain Logistics Scorecard were judged too complicated and too difficult to use, especially when dealing with small and medium enterprises (Banomyong, 2008).

The maturity of SCM practise in the UK appears to be somewhat variable. For example, within the grocery and automotive sectors can be found examples of world class performance. Tesco is twice as profitable as the grocery industry average and has led the way in terms of supply chain and logistics practise in the UK, (Potter et al., 2007). Nissan and Toyota factories in UK are some of the most efficient car production sites in Europe. However, some 50% of the UK's GDP, and nearly 70% of UK employment, is in SMEs (CBI, 2000 cited in Quayle, 2003) and here supply chain management practises seem to be rather unsophisticated. In Quayle's 2003 survey of 480 SMEs, only 25% of SMEs had a strategy for SCM and of those only some 10% had a senior executive responsible for the supply chain, and 75% of them noted that traditional supply chain practise was a problem for them.

To emphasise the different national settings, the cultural differences between New Zealand, Thailand, and the United Kingdom are indicated in Table 1 using Geert Hoefstede's (1980) cultural dimension values.

Cultural Dimensions	Definition	NZ	Thai	UK
Power Distance	The degree of equality, or inequality, between people in the country's society	22	64	35
Individualism	The degree the society reinforces individual or collective achievement and interpersonal relationships	79	20	89
Masculinity	The degree the society reinforces, or does not reinforce, the traditional masculine work role model of male achievement, control, and power	58	34	66
Uncertainty Avoidance	The level of tolerance for uncertainty and ambiguity within the society - i.e. unstructured situations	49	64	35
Long-term Orientation	Society's time perspective and an attitude of persevering; that is, overcoming obstacles with time, if not with will and strength	30	56	25

Table 1. Cultural Dimensions (Hoefstede, 1980)

In Thailand, if these societal norms are carried over into supply chain practise, one might expect to observe a very strong/domineering leader and a strong leadership doctrine; extensive use of standard operating procedures, forecasting and other models, and many tightly formalised supplier and customer relationships – all aimed at reducing supply chain uncertainties; a prevalent group/process view, with a team equally comprised of loyal male and female staff with no great sense of self importance; finally, the Thai organisation will tend to adopt a long-term view of business. In New Zealand, if its societal norms are carried over into supply chain practise, one might expect to observe a consensus style of leadership; some evidence of SOPs, forecasting and other models and some supplier relationships to reduce supply chain uncertainty; and probably prevalence of a silo view of the organisation. In the UK, if its societal norms are carried over into supply chain practise, one might expect to observe a clearly-defined leader who others look to for direction; relatively rare occurrences of standard operating procedures (SOPs) and forecasting and other models, and loose supplier relationships that would increase supply chain uncertainty; and again a prevalent silo view. Because New Zealand and the UK rate similarly on three cultural indices, if such societal norms are carried over into supply chain practise one might expect to observe in both of these countries individuals with egos who do not automatically feel loyalty to the organisation and its leader; male-dominated decision-making; and a tendency for the organisation to adopt a short-term view of business. These expected practises are summarised in Table 2.

	Leadership Style	Staff Loyalty	Business Orientation	Silo or Process View	Use of SOPs and Models	Extent / Nature of SC Linkages	Decision Making Style
NZ	Consensus	Possibly loyal individuals	Short-term	Probably silo	Some	Some formal	Male bias
Thai	Strong/ Domineering	Probably a loyal team	Long-term	Probably process	Extensive	Many, tight, formal	Male / Female
UK	Clearly-defined	Possibly loyal individuals	Short-term	Probably silo	Rare	Loose	Male bias

Table 2. Culture: Posited implications for supply chain practice
(Authors following Hoefstede, 1980)

The underlying logic of our research perspective to be tested is illustrated in Figure 1, in which the behaviour of supply chain managers is considered to be affected in four separate ways by the national culture and business setting. Firstly, the alternative norms, expectations and values of different nationalities provide a broad cultural setting for supply chain management decision making. These values often also affect the organisational culture based on country of origin (Aycan et al, 1999; Schmeider, 1988; Ralston et al, 1997). However, the specific organisational culture may differ from the national norms to have a different affect on supply chain management behaviour (Von Glinow et al, 2002). In many instances the individual supply chain managers are from different countries than the organisation in which they are employed. As a result an individual's cultural background will also affect supply chain management behaviour; at times contrary to the national setting. Finally Figure 1 indicates the possible effects of the national business setting on the behaviour of supply chain managers.

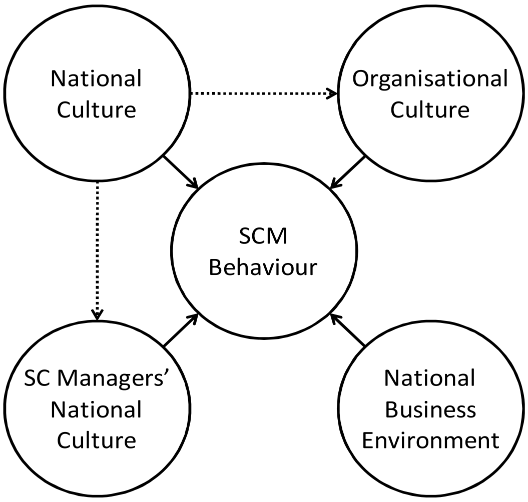

Figure 1. National Cultural Factors Affecting the Behaviour of Supply Chain Managers

METHODOLOGY

In order to conduct exploratory research into supply chain cultural behaviour a thorough investigation of the behaviour of supply chain managers is required (Metters et al, 2010); since detailed comprehension of the actions, values and norms of supply chain managers is necessary. The target data concerns how these individuals act according to their own national culture, which may be moderated to an extent by the wider work place culture and national setting. Through the application of standard research protocols (Naim et al, 2002) anthropological data was acquired by an international team of practise based researchers in five countries. This was combined with insights from action research projects and from long term collaborative research relationships. All this first hand face-to-face primary observation data of supply chain managers in action provides a rich stream of supply chain cultural data.

ETHNOGRAPHIC STUDY FINDINGS

Through many hours of direct observation and enquiry the behaviours of a wide range of supply chain managers was collected. A number of similarities in the behaviours were observed. Table 3 categorises thirteen supply chain manager types identified from the international sample, including the non-existent supply chain manager. The most salient examples of each of the twelve supply chain management types are now discussed.

Manager type	Description	Case Occurrence
SC manager as Obstacle	An immoveable object that will not pass on information or agree to any form of change. Promoted over time from a shop floor trainee, minimal qualifications but in charge of a sizable budget. Due to lack of relevant experience and expertise all decisions are delayed.	NZ heavy machinery NZ health sector NZ dairy industry UK auto heat treatment
SC manager as	A live wire reactive manager, keen to keep an eye	NZ 3PL

Firefighter	on operations and participate in strategic decision making. Lacks a holistic view and any real sense of direction. Busy being busy putting out operational fires that recur because the root causes are not addressed.	NZ heavy machinery NZ forging NZ commodity w'sale UK auto components
SC manager as Administrator	Procedural based management. Task orientated with specified goals as agreed in committee meetings. Slow in responding to external stimulus. The focus is more on being seen to have made the right decision rather than making the right call.	NZ health sector NZ forging UK auto systems
SC manager as Commander	Direct command and control of multiple levels of decision making. All initiatives come from above and directives are issued to the troops. The SC operates as a ship of the line and is as polished as possible within the limited imagination of one commander.	NZ FMCG German auto forging
SC manager as Negotiator	A key intersection of functional heads and external interactions makes for a potentially powerful position for the SC manager. Here sides are drawn and the managers utilize their position to further their goals.	NZ dairy industry UK auto systems UK aerospace systems
SC manager as Cost Accountant	Balanced and analytical approach to managing SCs. The costs of alternative value adding and other activity are carefully cross-checked with re-engineering alternatives to identify optimal efficiency. Can at times overlook the human element of SC operations.	NZ dairy industry NZ FMCG
SC manager as Coordinator	Linking the SC processes together across functional boundaries is a full time task for these managers. Acting as information conduits, filtering and passing relevant information to the different functions.	NZ FMCG UK Food Retail UK Milkshake
SC manager as Relationship Builder	Developing a shared view of the SC and bringing a range of stakeholders together to enhance SC performance. Good listening skills are coupled with charisma with the aim to educate key players for better SC decision making.	NZ primary producer UK auto components
SC manager as Change Agent	Dynamic markets and the focus on core competence require SC managers to constantly refresh their SCs. Keeping up with best practise, global sourcing and international trends. Continuous improvement is a mantra.	NZ primary producer UK auto systems UK lighting products
SC manager as Integrator	Synchronisation of material and information flows and the removal waste is achieved through a well orchestrated SC. Responsibilities are clearly defined and holistic trade-offs performed. Appropriate external interfaces are designed and operated.	UK auto systems UK FMCG
SC manager as Innovator	Creative and holistic entrepreneurs. As an information hub wider trade-offs and more innovative options can be developed. Open discussions with multiple SC personnel and a willingness to accept mistakes as part of learning.	NZ commodity wholesaler UK lighting products
SC manager as Leader	Clear, decisive yet considered and balanced. Overall effectiveness achieved through empowered leaders at all levels of SC management. Open and willing to learn; decision making is based on experience and reflection.	NZ Mass merchant

SC manager as Absentee	No one responsible for the SC, often leaving large procurement budgets un-checked and limited effort placed on cross-functional trade-offs…	A large number of cases

Table 3. Observed Supply Chain Manager Behaviour Types

In New Zealand supply chain education is lagging behind demand (Wen et al, 2009). As a result there is a significant skills shortage and those in supply chain positions have typically been promoted from within to fill a gap. These untrained and often myopic managers act as obstacles to supply chain effectiveness. These obstacles are frequently identified during audits in New Zealand and the need for up skilling promoted. "*I don't know what all the fuss is about SCM; our processes work OK and don't require fixing.*" Senior (nationality: NZ) supply chain manager in the NZ health sector.

In many New Zealand organisations there is also the need to be seen to be busy. Supply chain managers can often seem hyperactive; running from one emergency to another, expediting materials and constantly dealing with customers and suppliers to work out ways to cope with the daily noise of operations. A lack of formal analysis and reliance on tacit knowledge empowers the supply chain manager as an essential link of the value adding process. "*Everybody knows me, and I'm sure at times many people cringe when they see me coming as they are hoping my latest emergency doesn't affect them*" (NZ) Middle manager of a NZ heavy machinery organisation. For the Administrator supply chain manager the focus is more on being seen to make the right decision than it is to actually making the right call. These overly officious and nit-picking supply chain managers can provide structure and stability for those working in the supply chain. However the overall effectiveness of the supply chain is overlooked due to the obsession with static, outdated procedures. "*It's not my fault the customer didn't receive their order, all the forms are in place - by my count the product was dispatched*." Middle (NZ) manager in the NZ health sector

Some supply chain managers do have the power and influence to control their supply chain. In Germany we observed supply chain Commanders who influenced all supply chain decisions; no matter how trivial all questions were channelled to them. The front-line 'troops' were deemed only fit for undertaking operational tasks and the management of the supply chain was left to the single commander. "*All the operations work in synchrony with one another. I provide leadership and guidance for the lads.*" Senior (German) supply chain manager of a German automotive forging organisation

Knowledge is power and sometimes supply chain managers act as knowledge brokers. Being at the interaction of functions allows supply chain managers to collect valuable information and decide how to best leverage such knowledge. Further, the external linkages are used by these supply chain managers to influence internal colleagues. "*Work is a series of negotiations, the more influence we can bring to the table the more likely you leave with what you want*." Senior (NZ) supply chain manager of a NZ FMCG organisation

Numbers are the key to achieving optimisation and the measurement, control and management of business processes are based upon tangible outputs. The Management Accountant-type participates in all supply chain decisions, various trade-offs are calculated and efficiency is paramount. "*Let's run the numbers before jumping to an answer, the new commodity tracking spreadsheet will provide us with the optimal product mix*." Senior (NZ) supply chain manager of a NZ dairy organisation

Supply chains are complex and require managers that can coordinate all the various parts into a synchronised whole. These types of manager orchestrate the material and information flows so harmony is achieved across interfaces. The human element can be overlooked when aiming for regimented co-ordination. "*We make sure all the parts arrive in a kit so the next business process can run unhindered. People are starting to appreciate the value of full synchronisation*." Senior (NZ) supply chain manager of a NZ FMCG organisation

Organisations are collections of individuals who attempt to do the best for themselves and their department. Building and maintaining relationships between these individuals provides a great deal of understanding and wider trade-offs. In time these individuals are formed into teams that bridge boundaries for the wider supply chain goals. "*Being a supply chain manager is all about relationship management. I spend most of my time travelling from one meeting to another; gaining buy-in and building consensus*." (UK) Supply chain executive of a NZ primary producer

A great deal of organisational change affects supply chain operations and, likewise, supply chain change affects a large number of organisational functions. As supply chain managers view markets, competitors and internal competences they are well positioned to identify business dynamics. In response to these changing environments some supply chain managers champion continuous improvement and dynamic alignment of supply with demand. "*Things change and we have to keep up, if we are not improving then we are moving backwards*." (UK) Supply chain manager of a NZ primary producer

In line with supply chain theory some managers see their role as integrators. Here the manager acts as a facilitator for the connection of the various parts of the supply chain. External relationships are managed to best suit the supply chain objectives and information technology is often used extensively to interlink the various business processes and inter-organisational exchanges. "*The guys in Japan organise the supply chain, they schedule the delivery of raw materials and co-ordinate the call-off of final product and its delivery to best integrate with their UK assembly plant*." Senior (UK) supply chain manager of a UK automotive systems manufacturer

A small number of supply chain managers were observed to act like entrepreneurs. Given their excellent grasp of supply chain concepts and their appreciation of the business environment these managers create new supply chain approaches and tailor generic concepts for their specific use. Change and the motivation for change is central to their arguments with colleagues and the need for unique value offerings for customers is paramount. "*We had to compete with the cheap Chinese imports so developed an agile supply channel that could design and build new products alongside customers*." A (UK) supply chain executive of a UK lighting manufacturer

Supply chains require leadership at all levels, the final type of supply chain manager identified attempts to empower their people. Through education, clear direction, open and frank information exchange this type of supply chain manager acts as a leader. The motivation of doing the job is paramount; they are provided with training and other necessary resources to complete the task to the highest standard. "*My job is to get everybody singing from the same hymn sheet. I can't be everywhere at once so I delegate as much as possible*." Senior (UK) executive of a NZ mass merchant

DISCUSSION

The findings clearly demonstrate a wide variety of supply chain management behaviours. The potential links between national culture and these supply chain behaviours will now be discussed. The high level of individualism in NZ and the UK clearly relates to the supply chain manager as an obstacle. Here the individual manager protects himself to the detriment of everyone else. Conversely institutional collectivism creates teamwork, breaks down functional boundaries and fosters quality circles (Flynn et al, 1994).

These two Anglo-Saxon cultures score low on the long-term orientation cultural dimension and helping to explain the supply chain firefighters who predominantly focus on short term problem solving. This is directly opposite to cultures with longer term future orientation that foster continuous improvement (Flynn et al, 1994) and an extended supply chain planning horizon (Choi and Hartley, 1996).

The New Zealand culture has a low tolerance of uncertainty. As a result a large proportion of management time is spent on developing and adhering to procedures and giving rise to the supply chain administrators. Naor et al (2010) argue that cultures with low tolerance of uncertainty develop fact-based managerial decision-making as opposed to gut intuition. As described above, this is however not the case for any of the New Zealand supply chains studied.

The commander type of supply chain seems to relate to male dominance of the workforce in Germany and NZ, even though the low power distance of NZ society would suggest otherwise. The observation of supply chain negotiators inhabiting the cross-roads of information seems to relate to the dominance of the individual in NZ and the UK, as opposed to more of a collective/collaborative approach. Furthermore, low assertiveness has also been argued as a complementary factor when negotiating with suppliers and customers (Naor et al, 2010).

The cost accountant behaviour could be viewed as an extension of the administrative supply chain manager. Along the same lines, culture could be the motivator to avoid uncertainty and drive performance based on measurable data. In contrast the focus in the UK and NZ on individual relationships seems to result in the existence of supply chain relationship builders. A longer term orientation would seem to fit the supply chain change behavioural type (Naveh and Erez, 2004). Interestingly this is in contrast to the countries in which it was observed.

The very low power distance in NZ and the similarly relatively low index for the UK may explain the supply chain coordinator behaviour observed. Subordinate feedback is essential for this management style, where all supply chain business processes are viewed relatively equally. Low power distance also seems to play a part in the behaviour of the innovators, leaders and integrators as all require subordinate empowerment. The lower power distance allows for employees to make independent decisions irrespective of their position in the organisational hierarchy (Nakata and Sivakumar, 1996).

Given the exploratory nature of this study and the limited set of cases studied there is clearly a need for further research to confirm the behaviours of international supply chain managers. This conference article pertains to our initial research into the national diversity of supply chain culture. The next step is to link the alternative behaviours to resultant performance and attempt to find cultural matches between supply chain managers and national settings.

CONCLUSIONS

Our exploratory research into supply chain behaviour has provided some initial insight into the role national culture affects the way supply chains are managed internationally. A wide range of management styles were observed and in many cases these are clearly linked to the different national cultural settings. This brings into question the quest by researchers for generic and generalisable supply chain concepts. Hence our research highlights the shortcoming of universalism within the context of global supply chain management.

From a particularistic perspective the behaviour of an individual supply chain manager should be tailored to the national setting they are operating within (especially the cultural and business contexts). Our research indicates that supply chain managers who originate from a common national culture can behave quite differently according to the local national culture they operate within. This highlights the need to tailor the link between supply chain management behaviour (especially leadership skills) to specific national settings. For example, do South Africans make the best supply chain managers in New Zealand? or do Americans only make good managers of American supply chains? Is there multi-linearity between the national culture of the manager and the most suitable international supply chain context?

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REFERENCES - Available on request

DRY PORT DEVELOPMENT: A COMPARATIVE STUDY OF THE UK AND THE FAR EAST

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ABSTRACT
Purpose:
This paper reviews the development of dry ports in the United Kingdom (UK) and Far East. Dry ports in the UK are widely recognised as models for similar facilities which have been developed elsewhere. They are invalidly strategically located close to main population and industrial centres. The development of Inland Container Depots (ICDs) in the United Kingdom started in the 1960s based on the growth of container shipping which drove, and continues to drive, the need of multimodal transport. In the United Kingdom, two major effects have shifted the overall trend towards containerised shipping. (i) Ports in the south-east of the country were more attractive to shipping lines because of their proximity to continental Europe and (ii) major producers and owners of cargo were often no longer located conveniently near the port at which their cargoes were handled. However, in the case of the Far East, the emergence of "off-shore" ports is driven not by proximity to main population or industrial areas but by the need to support the rapidly growing container flows. Under the framework of ASEAN+1 (ASEAN and China), the development paths of Far East Ports have shown some differences in comparison with United Kingdom. This paper highlights and explains these differences.

Research approach:
From commercial companies and first hand field work, data were obtained over a period of six months. An international comparative study was carried out in both the United Kingdom and in the Far East. A theoretical basis for this study is provided by a spatial analysis of several countries using König numbers as an analytical tool.

Findings and Originality:
It is shown that the demand for ICDs in the United Kingdom has reduced due to the expansion of the European Union which had led to the streamlining of customs clearance processes. In turn this has reduced the need for conventional clearance points in the case of European Union sourced trade. In the Far East, however, there is no equivalent customs clearance regime with result that, given the rapid growth in trade in the region, there is potential for large scale expansion in ICDs which take the form of "off-shore" ports.

Research impact:
By using König numbers as a basis for analysis, various phases of "off-shore" port (ICDs) development could be modelled to provide a strategic tool for improving port and logistics chain efficiency.

Practical impact:
In practice, this research could be used for identifying fresh decoupling points in supply-chains, especially where large volume of goods is moved internationally via the sea ports. Further, this modelling approach, founded on the early ICDs strategy of the UK, can contribute to reducing congestion in the ports.

Keywords: Inland Container Depots (ICDs), Dry port, port congestion.

INTRODUCTION
Since the advent of containerisation, the freight transport industry has gradually shifted from the traditional Port - Port concept towards a 'total system' approach. This has stimulated the growth of multimodal transport, and Dry Ports have emerged as a means of making better use of inland infrastructure and hence improving the overall efficiency of international logistics. The containerised trade has penetrated further inland and

volumes have risen substantially with the consequence that cargo traffic through seaports has created congestion, especially with modern manufacturing systems focusing on decoupling points in order to strategically position their cargo.

Dry Ports have thus become an integral part of logistics by extending seaport functions inland. There are a number of titles used for Dry Ports which include Inland Container Depots, Container Freight Stations and Containerbases. For the purposes of this paper, the term 'Dry Port' is used to cover all such facilities.

There are three principal reasons for the establishment of Dry Ports around the world, namely:

- The constant need to improve the efficiency of inland transportation.
- The ever-growing congestion in land areas around major ports (and concomitantly, the lack of available back up space for handling the increasing volume of container/cargo flows).
- The transformation of shipping from a 'port-to-port' activity to an integral component of logistics operations.

UNESCAP (2009) provide a detailed framework on the philosophy of Dry Port development, capturing both generic principals and details specific to individual countries where Dry Ports have been established.

THEORY OF DRY PORT LOCATION

A key aspect of the establishment of Dry Ports is the question of location. At the centre of the locational inputs is the König number which is a measure of accessibility set against the existing transport network and the distribution of centres of output and consumption (Beresford and Dubey, 1990). Specifically, the König number is a measure of how many links between nodes (population / industrial centres) freight must pass through in order to move from one extremity of a network to the other. The higher the König number the more links freight consignments must travel along in order to traverse a given network. The lower the König number, the more accessible or central the location. The König number therefore enables all possible locations to be indexed by accessibility and the lower the number the better the location for Dry Port development. In all cases Dry Ports are established with good location and strategy in mind. However, there may be regional variations driven by, for example, government policy or geographical constraints. These constraints act as an overlay to spatial network as initially defined by König numbers.

By using König numbers as a basis for analysis, various phases of Dry Port development can be modeled to provide a strategic tool for improving port and logistics chain efficiency. Further, Dry Port implementation can contribute to reducing congestion in the ports. However, little research has been carried out which combines the concept of Dry Ports, with supply chain management and the use of locational modeling tools such as König numbers.

FUNCTIONS OF DRY PORTS

Dry Ports have been established at different times depending on the circumstances in particular regions. With the expansion of containerisation during the 1950s and 1960s came opportunities to reorganise the logistics of unit load movement. By the 1970s Dry Ports had become an integral and well-established part of the inland container transport system, especially in the United States and Europe where inland penetration of containerisation was at its maximum. The core function of a Dry Port can vary slightly depending on the country concerned, although attempts have been made to define the concept in terms of core functions. For example, Roso (2008, 2009) suggests that 'a Dry Port is an inland terminal directly connected with high capacity transport means where customers can leave/pick up their standardised units as if going directly to a seaport'. In practice, most Dry Ports focus on road-rail intermodal transfer and customs clearance of containers and containerised cargo. In terms of the access to a Dry Port there is no reason why it cannot be a road-road or road-waterway facility depending on location and available infrastructure.

Dry Ports usually perform an additional range of functions beyond that of intermodal terminal transfer and transport connections. Such 'ports' aim to solve main port congestion and relieve land pressure; the Tioga Group (2003) refer to the 'inland port' concept as one where '… some seaport facilities could be duplicated or complemented at inland locations, thus reducing the need for scarce space at the seaport'.

THE DEVELOPMENT AND EXPANSION OF DRY PORTS
The USA and Western Europe were the first regions to exploit the advantages of moving some of the ports' functions inland by establishing Dry Ports. Lloyds Maritime Atlas (15th Edition) attempted, for the first time, to map the world's Dr Ports; the Atlas indicated that in the mid-1980s there were about 150 facilities in North America, 130 in Europe and around 400 worldwide (Beresford *et al.*, 1987). More recently, developing countries such as India and Thailand have established several near-to-port or remote Dry Ports. A study by UNESCAP (2006) estimated future Dry Port requirements in the Asia/Pacific region will be for an additional 200 Dry Ports by 2015, expanding the total in the region to approximately 312.

The general increase in demand for Dry Ports, and their flexibility in form and design, has facilitated ports' modernisation programmes such that they are now taking on fresh dimensions by acting as logistics hubs, freight villages, and distribution centres which contribute to encouraging trade by meeting commercial demands in line with lean and agile logistics concepts (Paixao and Marlow 2004). Dry Ports are likely to strengthen their role as an integral part of shipping and globalisation strategies.

United Kingdom
The development of Dry Ports in the UK commenced during early 1960s as a result of the shipping industry's increasing use of containers for general cargo shipments. An example was the P&O operated Containerbase in Birmingham which was opened in December 1968, and others in Glasgow and London shortly afterwards (Ingram, 1992).

In the UK two major effects arose from the change to containerised shipping:

- Ports in the south east of the country were more attractive to shipping lines because of their proximity to continental Europe and;
- The major producers and owners of cargo were often no longer located conveniently near to the port at which their cargoes were handled.

Effectively the sea-border was 'moved' to approved Dry Ports and they became the points at which goods effectively entered or left the country (Ingram, 1992).

In the UK, Dry Ports are run by various consortia, usually as an extension to existing business operations. The largest group consisting of six depots, the Containerbase companies, was established by P&O, the major deep sea shipping line (with other share-holders) as a distribution network for their 'Through Transport System'. Five of these depots were situated next to railway lines, so that they could be linked with the ports of Tilbury and Southampton by over-night trains. These Dry Ports were clearly transport nodes, as well as cargo clearance depots. Other Dry Ports, notably the London and Manchester International Freight Terminals were established by British Rail, and grew out of the existing businesses of packing railway wagons for transportation by train ferries.

Privatisation of the ports in the 1980s brought changes to the ownership and management structure of Dry Ports and, in the 1990s Roadways Container Logistics (RCL) was formed. A combination of takeover and re-branding led to the P&O operated Containerbases becoming part of the AP Moller Group, under the title Maersk Line but retaining the original brand identity of P&O. In December 2008, a further ownership change occurred when RCL was sold by the AP Moller Maersk group to privately owned Aegis Transport Ltd. The Containerbases were thus taken on by ATL with no change to their operational brief (Anon, 2008). Containerbases therefore play a dual role in firstly providing Dry Port services for a wide range of shipping lines, and secondly inland container logistics for land based distribution involving both road and rail. The main characteristics of Dry Ports in the UK, where a substantial amount of unitised freight originates or finishes inland, are summarised in Table 1 . The connectivity of these conurbations by major road or rail links allow the UK space to be resolved into a node-network diagram. The closer to the centre of the diagram, the better a potential location is for a Dry Port. The complexity of industrial population and distribution however results in a clustering of Dry Ports in certain areas such as the industrial zones around London, Manchester and Glasgow. In all cases the logic of these locations fits the König number calculation which shows the Dry Ports to be in least-cost, maximum accessibility positions.

UK Dry Port Ownership Structure	Private (100%)
Governing Board/ Approving Authority	HM Customs
Date of Commencement	Mid 1960s
Rail /railhead from port to Dry Port	Private (100%)
Road from Port to Dry Port	Ministry of Transport
Inland Waterways transport to Dry Port	Indirect via road
Distance, Port to Dry Port	below 350km
Multimodal Transport Links from Port to Dry Port	Many alternative routes
Regional Transport Policy Context	Closely connected to EU transport policies
Guidelines for Dry Port Operations	HM Customs
Competition	High
Labour	Skilled/Semi-Skilled/Private
Security for Dry Port	Infra-red CCTV & alarmed fencing
Computerisation of Port/ Dry Port	Highly connected
Environmental Standards	Adhere to EU standards
Cargo Flows/ Direction from Port to Dry Port	Hinterland (whole of UK)
UNCTAD recognition of Dry Port operation	Yes
Quality Assurance	ISO9002
Service Network: Port - Dry Port - final destination	Containerbases, Roadways transport & 3PL providers
Seaport delays due to logistics weaknesses	Periodic
Traffic Congestion, Seaport	Low / Medium

Table 1. Key Features of Dry Ports in the UK

The demand for Dry Ports in the UK has reduced due to the expansion of the European Union (EU) which has led to the streamlining of customs clearance processes. In turn this has reduced the need for conventional clearance points in the case of EU sourced trade. In the Far East, however, there is no equivalent customs clearance regime with result that, given the rapid growth in trade in the region, there is potential for large scale expansion in Dry Ports which take the form of "off-shore" ports.

Far East

In the Far East, the major producers and owners of cargo are often not located near to the ports at which their cargoes are handled. However, the emergence of Dry Ports (sometimes referred to locally as 'offshore ports') is driven not by proximity to main population or industrial areas but by the need to support rapidly growing container flows. Under the framework of ASEAN+1 (ASEAN and China), the development paths of Far East Dry Ports have been somewhat different when compared to the UK. These differences are now discussed.

Indo-China

The establishment of Dry Ports in Indo-China first took place in Malaysia and Singapore. During the early 1980s a suite of Dry Ports was developed to better service the growing containerized trades which were focused on the major gateway ports and the largest inland cities. Thus, for example, four Dry Ports were established in Malaysia in the vicinity of Kuala Lumpur (Sungai Way), further north at Ipoh and in two coastal locations at Penang and Butterworth. They were all associated with industrial parks mainly focused on export, and Sungai Way had a dual function of handling import cargo for Kuala Lumpur as well as export oriented output.

More recently, the government of Thailand devised a Dry Port development strategy with the Thailand International Freight Forwarding Association (TIFFA) as a major participant. The application of the Dry Port concept to land / sea logistics in Thailand was first suggested in 1989 by the Japan International Cooperation Agency (JICA). The JICA study concluded that a large Dry Port would be required as a backup facility to support the rapidly growing industrial base in Thailand. By early 1993 the land necessary for such a facility had been acquired by the government. The State Railway of Thailand was then authorised to commence the design and construction. The facility was completed in 1995 and operating concessions were granted such that the private sector would play a major role in running the Dry Port. Operations commenced in March 1996.

The facility at Lat Krabang (on the outskirts of Bangkok) is now one of the largest Dry Ports in the world situated 118 kilometers from the deepwater port of Laem Chabang; the Dry Port currently handles up to one million TEUs per annum having handled 291,295 containers in its first full year of operation (1997). There are six independent cargo handling companies at the Dry Port (as detailed in Table 2) and up to twenty six rail arrivals and departures per day are serviced. The operation of Lat Krabang is under the supervision of SRT (State Rail of Thailand). According to the Thai Marine Department, rail services in between these two locations are responsible for 25% of containers handled at the Laem Chabang Port. According to SRT, approximately 83.93 per cent of rail freights are bound for ports and ICDs. Within that, about 94.92 per cent of the 82.54 per cent of freights are containerised cargoes which are characterised as intermodal transfers between Laem Chabang Port and Lat Krabang ICD. This shows the level of intensity and importance of intermodal rail services in between ports and ICDs.

The strategic function of this Dry Port is twofold; firstly to service the industrial areas of greater Bangkok and secondly to act as a national distribution centre for containerised cargo (Chao and Beresford, 2009). The accessibility of Bangkok from the south, north and east by rail / road means that the Dry Port at Lat Krabang is virtually at the geographical centre of Thailand and hence it is optimum in terms of its König number. For several years the freight modal split between road and rail has been consistently around 70 percent – 30 percent which emphasizes the important role played by both methods of transport.

Module A	Siam Shoreside Services Ltd.
Module B	Eastern Sea Laem Chabang Terminal Co Ltd.
Module C	Evergreen Container Terminal (Thailand) Ltd.
Module D	TIFFA ICD Co. Ltd.
Module E	Thai Hanjin Logistics Co. Ltd
Module F	NYK Distribution Service (Thailand) Co Ltd.

Table 2. Module Operators at Lat Krabang

China

The rapid growth of trade through Chinese ports has put considerable pressure on inland distribution systems, especially near to the well-known major gateways. Around the year 2000, therefore, China embarked on a development programme for Dry Ports in order to improve inland connectivity, and rail-waterway-road linkages and to facilitate trade. The notable example of Dry Port development is seen at Guanlan which is located around one hour from the major Hong Kong terminals. Particularly important are the road and rail links to HIT’s facilities, the Yantian Port free-trade-zone, and Shenzhen and Hong Kong international airports. Unusually, therefore, the Guanlan Dry Port (known as GICD) acts as a multimodal cargo consolidation and distribution centre, embracing land, water and air logistics. Within its region the GICD is again very well located and very accessible, and hence it scores a low König number.

The facility was one of the first to widely use GPS for cargo positioning, and in many respects the terminal is at the cutting edge of ICT applications in trade and transport, bundling cargo information into the Guanlan Inland Depot Operation (GIDOS) system. This embraces:

- Customs export consolidation
- Quality Inspection, and
- Value Added Services

The latter includes:

- barcode production
- labeling and relabeling
- pick and pack,
- Sorting and Kitting,
- Wrapping and Palletising and
- Other Services

Strategically the aim of the facility is to act as one-stop-shop for international logistics services embracing all the modes of transport, as well as value addition. Such a range of services is very unusual, and it is notable that a large proportion of the Dry Ports surface area is allocated to cargo storage and value addition activities; Elsewhere Dry Ports are normally geared to interfacing marine and land transport with less emphasis on cargo storage and manipulation. Critical to the success of the Guanlan facility is its location combined with its marine / land accessibility. Within South China, Guanlan is centrally located, thus generating a low König number which in turn implies low aggregate inland transport costs.

CONCLUSIONS

Dry Ports in the UK were effective in encouraging the integration of port, sea, road and rail freight operations. In terms of ownership, they are all private with regards to provision and funding of facilities; government participation is limited to the unfettered role of HM Customs in ensuring cargo security and trade legitimacy. This approach has worked well and has formed a model for Dry Port development in a number of countries worldwide. The growth of the UK economy during the 1980s provided the impetus for increased cargo flow and encouraged large scale modernisation and infrastructure development. This in turn encouraged investment in logistics infrastructure and greater integration of third party logistics. By extension, this facilitated the development of Dry Ports close to all the largest urban or industrial centres.

In the Far East, where development of Dry Ports began several years later, there are now many examples where they now play a significant role in facilitating the movement of cargo between marine and land transport modes. Prominent amongst these are the Dry Ports of Malaysia, Thailand and China. Although they vary in terms of scale and function, they have a number of common characteristics. Underpinning all Dry Ports is the importance of location expressed in terms of accessibility and connectivity. It has been shown that these elements can be satisfactorily captured by the use of König numbers which enable the optimum location for such facilities to be identified.

Dry Ports play a major role in the facilitation of international trade and logistics, and an additional role in encouraging efficient regional transport and distribution. In general, Dry Ports operate along similar lines in both developed and less developed countries, although every country has its own specific needs according to circumstances.

REFERENCES

Anon. (2008) Maersk sells Roadways. **World Cargo News** - Inland / Intermodal News, Dec. 2008. p.16.

Beresford, A.K.C. & Dubey, R.C. (1990) **Handbook on the Management and Operation of Dry Ports**, UNCTAD, RDP/LDC/7, Geneva, Switzerland.

Beresford, AKC, Dobson, H.W and Holmes, C (1987) **Lloyd's Maritime Atlas of World Ports and Shipping Places**, Fifteenth Edition, Lloyd's of London Press Limited, Colchester.

Chao, P and Beresford, A.K.C. (2009) **Multimodal Transport: The Trading Corridor between Thailand and China in the Greater Mekong Subregion**. Proceedings of the Logistics Research Network 9-11th September 2009. Cardiff, UK.

Ingram, RAH (1992) **The Development of Inland Clearance Depots**, 1952-1992-International Cargo Handling Coordination Association (ICHCA)-40th Anniversary Review. pp 85-87.

Paixao AC and Marlow PB (2003) Fourth generation ports-a question of agility, **International Journal of Physical Distribution and Logistics Management**. Vol.33, No .4 pp 355-376.

Roso, V (2008) Factors Influencing Implementation of a Dry Port**, International Journal of Physical Distribution and Logistics Management**, 38 (10), pp. 782-798

Roso, V (2009) **The Dry Port Concept,** PhD, Chalmers Institute of Technology, Göteborg, Sweden, 310 pp.

State Railway of Thailand (2005) **Lat Krabang Inland Container Depot**, State Railway of Thailand, Container Transport Bureau, Bangkok, 12pp.

Tioga Group (2003) **Inland Port Feasibility Studies**, prepared for San Joaquin Council of Governments, Moraga, California.

UNESCAP (2006) **Cross cutting issue for managing globalisation related to trade and transport. Promoting Dry Ports as a means of sharing the benefits of globalisation with inland locations**. http://www.unescap.org/cmg/2006/CMG3-I/English/CMG3-I_1E.pdf

UNESCAP (2009) Transport and Communications Bulletin for Asia and the Pacific: Development of Dry Ports. No. 78. Draft. New York.

PROBLEMS AND CHALLENGES FACING A MARKET ORIENTATED SUPPLY CHAIN APPROACH

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INTRODUCTION

Adopting a market orientation approach has been advocated by numerous authors as central to individual firm performance (*Narver and Slater, 1990*) yet, significant to this paper, it is the "foundation for managing supply chains" (*Min et al., 207:517; Erevelles and Stevensson, 2005*). Scholarly definitions of market orientation derive from a theory indicating three pillars (or constructs), founded by *Kohli and Jaworski (1990).* These pillars are termed as "behavioural components", to include a customer focus and coordinated marketing, both of which further lead to profitability. Many authors also contrast or link these definitions with Narver and Slater (1990) who distinguish the features of each pillar as behavioural components and decision making criterion.

With these definitions as a consideration, the paper, initially, highlights the most influential authors who have contributed to the theory of a market orientation. The specific identification of key authors leads to a set of defined features to characterise a market orientation. The central objective of the paper is to challenge, that independently, a market orientation, by virtue of the established definition, is a true panacea to improve organisational performance, and more significantly, supply chain management. The paper further questions if it is possible to balance the proposed set of characteristics, to achieve a full market orientation. These objectives together, frame the fundamental aim for this research paper; an evaluation of the literature determines whether the adoption of a market orientation is still believed to be the correct pathway for organisations operating within the current market place, which can be characterised by extreme competition and unpredictable demand levels. This conclusion leads to the design of a questionnaire to be later circulated within the selected case study industry.

The paper is structured as follows: at the outset, an original contribution of this research is to demonstrate that the theory of a market orientation is still a relevant topic of interest for both researchers and industries, and significantly, has not been exhausted (*Henderson, 1998*). Once this has been established, the paper highlights key challenges or issues that may present a negative impact, on organisations and their constituent supply chains, whilst trying to be market orientated (*Harris and Piercy, 1997*). This leads to a series of questions to be later tested within a suitable industry environment. The questions address two key issues: the position of recovery from the recent global recession, but to also to confirm any likely challenges or potential conflicts that management encounters when trying to adopt a full market orientation approach.

The UK touring caravan sector provides a useful platform to apply this research, enabling a focused study within a niche sector. The industry is further considered suitable, due to many parallels identified, which implies that the research findings may be relevant to other industry sectors.

In essence, this paper focuses on the following questions:

1. Who are the key authors, linking the theory that "market orientation" can be a significant contributor to competitive advantage within organisations?
2. What are the likely challenges or potential conflicts that management encounters when trying to adopt a full market orientation approach, linking all three defined pillars?
3. Is the adoption of a full market orientation, independently, the correct response for organisations in today's marketplace?

RESEARCH BACKGROUND

The paper builds on the findings from *Lynch et al., (2009; 2010).*The research background is divided into two sections. Firstly, the term, orientation is explored and secondly the term is aligned to the marketing concept.

Orientation as a term

The theory of orientation has received considerable attention by authors across disciplines within business management. For example, it has been suggested that orientation (or function) plays a fundamental role in achieving business success *(Pearson 1993).* This implies that there is a challenge for managers knowing how to select the appropriate orientation for business direction and focus. This becomes even more of a dilemma when trying to manage the supply chain, and furthermore, if managers are suddenly faced with economic uncertainty or other "external shocks" *(Lynch et al., 2010)*. To consider the extensive range of orientations that have been theorised in past literature, *Lynch et al., (2009*) identify some of the most commonly referred orientation types, such as a production orientation, a customer orientation and a supply chain orientation, and subsequently, some proposed time phases or eras *(Keith, 1959; 1960)* are challenged. Conversely, *Zhou and Li (2010)* refer only to a "strategic orientation" which actually endorses the need for three orientations: the customer, the competitor and technology *(Gatignon and Xuereb, 1997; Voss and Voss, 2000).* All orientation definitions appear to indicate that market intelligence should be promoted across all business functions; not just within marketing (*Kohli and Jaworski,* 1990) but with so many developed definitions of market orientations as a concept, all claiming to improve business performance, this study queries which author has become the most influential within the vast numbers of literature published.

The most influential definition for a market orientation

The second part of the research background addresses question 1. This is an important pre-requisite, providing justification and a link to answering key questions 2 and 3 in the research findings.

There is no doubt that the theory of market orientation is well established in the academic literature with early mention, as a phrase, in Harvard Business Review *(Schurr, 1949; Dean, 1950).* The question that is addressed, initially, is to determine which key authors have been most influential, by virtue of definition, to advocate the implementation of a market orientation? Yet, pinpointing clear early definitions, of what exactly a market orientation entails, appears to be varied yet confined to a few key author views. This is determined through a study of citations which indicates there is a high contribution to theory, further establishing some clear influential definitions.

An initial Google Scholar search predicts "about 40,600[4]" documents using the term, market orientation. The Google Scholar search highlights 3,001 citations for *Kohli and Jaworski (1990).* These authors appear to be the first authors to identify the "construct", the "propositions" and the "managerial implications". The paper is published during April (1990) as a response to *Shapiro (1988)*, who crudely questions, "what the hell is market orientated"? As a further consequence, *Kohli and Jaworski (1990)* characterise the adoption of a market orientation as facilitating the creation of superior value within the organisation. *Narver and Slater (1990)* further develop this definition with a set of behavioural components and decision making criteria, in their efforts to link market orientation with business performance. The full definitions can be seen in Table 1.

With these two parallel papers in circulation, at the outset, an original thread to this research paper identifies that Narver and Slater (1990) have become the most influential authors. The Google Scholar search significantly reveals 3,029 citations for this paper. To triangulate the method employed, ISI Web of Science database confirms Narver and Slater (1990) as major contributors to the theory of market orientation. It has not been

[4] Google Scholar search conducted 21/04/10, results show n = "about 40,600" articles in 0.18 seconds

established if this is due to the definition or the claimed links to improving business performance.

Kohli and Jaworski (1990) definition of market orientation	Narver and Slater (1990) definition of market orientation
Three pillars: Customer focus *(market intelligence is based on future needs)* / Coordinated marketing *(all functions need to be in tune with the customer)* / Profitability *(is a consequence of market orientation)*	**Three behavioural components:** Customer orientation / Competitor orientation Inter-functional coordination **Decision Criteria** Long term focus / Profit objective

Table 1: Two key definitions of a market orientation

Whilst the key authors are firmly established, in addition, the study questions the relevance of these market orientation definitions, in contemporary literature; has the debate surrounding what constitutes a market orientation been completely exhausted (Henderson, 1998)?

The current significance of adopting a market orientation

A general search using ABI Inform Proquest database, lists 1,000 articles, published since April 2008, using the term market orientation. The results of an ISI Web of Science search, shown in Figure 1, confirm that market orientation has received a considerable rise in interest during the set time frame of 1990- 2009, significantly, still linking Narver and Slater as key authors[5].

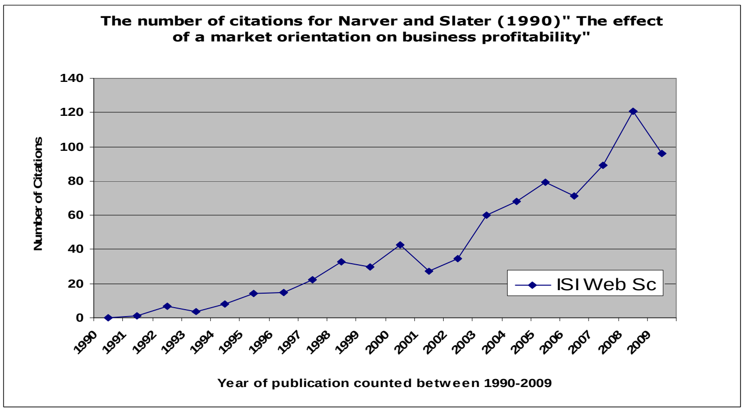

Figure 1: An implied trend in the use of citations for Narver and Slater (1990)

RESEARCH METHOD

The research design is divided into two elements: secondary and primary data collection.

First element - Approach to the literature review

For the first element, an initial literature search is undertaken using a general Google web search and University School electronic journal search. The search is tightened to include Google Scholar and University electronic database access. This systematic approach enables an evaluation of the literature available to establish the relevance of market orientation whilst highlighting some key authors who provide some clear definitions for a market orientated approach. In addition, the method is selected to establish whether this is still a contemporary issue, subsequently, providing the scope for further investigation. The initial citation search utilises three suitable databases. These are: Google Scholar; ISI Web of Science and Scopus. Table 2 appraises all methods employed to arrive at the evaluation. These findings may be of relevance to other researchers.

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[5] A significant limitation to this search however, is the basis for comparison. The search engines do not allow you to compare like for like, just year on year changes For example, there has been a tremendous growth in interest for issues surrounding market orientation, yet, there has also been a significant growth in the number of journals introduced and consequently papers published since 1990.

Method	Rationale	Search Terms	Benefits	Limitations
Google web search	List any article using a specific term	Market orientation	Easy access; User friendly	Too broad for credibility and quality; lists non relevant information
Google Scholar Database	List scholarly articles using a specific term; Citation search	Market orientation; citations for Narver & Slater (1990)	Easy access; User friendly; Ranks in order of significance; Provides links for citations	Search too wide; does not rank by relevance or date; Only lists first 1,000 documents
ISI Web of science Database	Citation search	Market orientation linked to authors Narver and Slater (1990)	Ability to tailor search by years, publication types, search terms; When repeated, is reliable	Not as user friendly as Scholar; Takes time to filter the information required
Scopus Database	Citation search	Market orientation Narver and Slater (1990)	User friendly; Provides a focused and reliable set of results	Unable to trace citations beyond 1994, therefore unsuitable in this study
ABI inform Proquest Database	Publication search (by year)	Market orientation	User friendly; easy access for abstracts, papers, etc	Is not able to facilitate a citation search

Table 2: The research approach to explore the significance between *Narver & Slater (1990)* and term, "market orientation"

A pilot study shows discrepancies using both Google Scholar and Scopus as reliable databases. When the search is repeated, the data set changes slightly, altering both the number of citations and years for the publications. Further measures are taken, such as using different IP addresses and conducting the search at different times of the day. These methods are used to test the level of accuracy and reliability of the findings. The pilot study confirms Google Scholar is useful to establish key authors. The ISI Web of Science is established to be the most reliable source, for a full citation search, to improve the quality of the data set, in preparation for analysis.

Second Element - Approach to the primary data search

The first element provides the main focus of this study, evaluating the literature for both the initial and fundamental research questions. The second element of the study, to answer questions 2 and 3, is partly empirically based. The literature findings identify that a market orientation can be defined by three distinct pillars. The characteristics of these pillars are used to support the design and structure of questionnaires to be circulated.

For the purpose of this paper, of which, the submission deadline is timed during the peak trading season for the case industry; the questions are, nevertheless, piloted with a selected range of case study personnel and consumers. Face to face interviews and email correspondence are used to trial the survey questions. The use of pilot studies provides opportunity to test the "face validity" (Saunders *et al*., 2007:386) of the questionnaire, to a sample size, to represent a generic view for both the industry and end consumers. The approach also provides a set of tentative findings to enable some comparison with the literature evaluation. The sample size and approach to be taken is illustrated in Table 3.

This is a focused study, taking the UK touring caravan industry as the case example. The UK caravan industry is a small, but nevertheless significant, sector of the UK economy accounting for £1.6 billion of turnover annually *(Timms, BERR 2007).* The sector is chosen as a suitable case study arena, primarily for two reasons. Firstly, current trading patterns in the sector during the recent challenging economic conditions have not been untypical of those seen in many other industries. Drawing this parallel provides a basis to assert that the research has some generic implication for other industries. Secondly, the authors have developed good access links to leading players throughout the caravan industry supply chain. Finally, consumers are selected via membership of a caravan owners' club, which represents approximately 1,000,000.000 families (CC, Facts, 2010)

Pillar	PARTICIPANTS	SAMPLE SIZE	METHOD
"Customer orientation" "Competitor orientation"	Consumers (Touring caravan owners)	Pilot (45)	Face to face interviews
"Customer orientation" "Competitor orientation" "Inter- Functional Coordination"	Industry supply chain 2 manufacturers 1 retailer; 1 supplier; 1 media 2 affiliated supply chain members	Pilot (20)	Face to face interviews; email correspondence

Table 3: Sample size and type for the pilot study questionnaires

FINDINGS

The role of market orientation within the concept of marketing

The preliminary literature searches provide substantial evidence that authors still consider market orientation and its implementation as a contemporary issue. Subsequently, it is important to first establish how the definitions are realised to determine what a market orientation actually requires. The, established, key authors, Narver and Slater (1990), imply that a market orientated organisation is one whose actions or operations are consistent with the marketing concept. Yet, definitions of the marketing concept differ in both their emphasis and interpretation. For example, *Deshpande et al., (1989)* align the concept with the organisational culture, *McNamara (1972)* underlines functional coordination, yet *Levitt (1960)* places the customer as the central focus. To align all definitions, the literature shows that a market orientation is in fact the implementation of the marketing concept *(Min and Mentzer, 2000).*

Despite the claims of performance improvement by key authors, Narver and Slater (1990), *Shapiro (1988:122)* places quite a critical perspective of managers' efforts to be market orientated "…just about every company thinks of itself as market orientated" suggesting most managers are "sheep in wolf's clothing". This implies that perhaps realising the full extent, or achieving a market orientation, is not an easy task, presenting issues in its implementation. This paper's findings, therefore, initially, consider question 2. The three earlier defined pillars are used to structure the findings, to identify any challenges or potential conflicts when trying to achieve a full market orientation.

Customer orientation - For organisations to be market orientated, it appears to be more than "just getting closer to the customer" *(Shapiro, 1988:119)*. In principle, it is a question of establishing marketing processes, such as ensuring the organisation as a whole aligns product with consumer needs *(Shapiro, 1988; Payne, 2001)*. This is perhaps even more challenging when, upstream within the supply chain, manufacturers operations, can be distanced from end consumer needs, yet, they still need to be market orientated or market driven. When customer needs change, customer orientated firms can respond appropriately, using the necessary resources to refine process or develop new products (Zhou and Li, 2010; Narver and Slater, 1990).

Competitor Orientation - The objective of a competitor-centred approach is to keep pace or remain ahead of the rivals, fully understanding their market position (Zhou and Li, 2010:225). Strong industry position tends to result in managers, gaining easier access to relevant information, to be able to respond to outside turbulence (Ottessen and Gronhaug, 2003).

Inter-functional Coordination - Figure 2 highlights the *Slack et al., (2009)* framework for operations highlighting the problems when trying to align operations with market demands. This challenge is further constrained by corporate objectives or strategy and the general day-to-day running of the business. Figure 3 is especially significant because in effect it encapsulates all three pillars outlined by Narver and Slater (1990). *Payne (2001:52)* emphasises there is no such thing as a "quick path to market orientation", further implying that the approach requires "a considerable challenge for management";

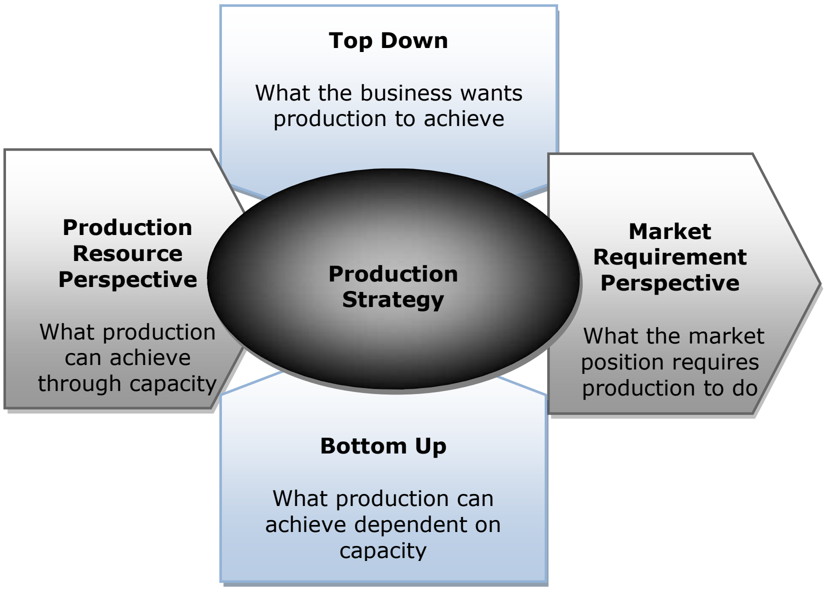

Figure 2: Four Perspectives on production strategy (adapted from *Slack et al., 2007:64*)

TENTATIVE INDUSTRY FINDINGS

Customer orientation – The pilot study highlights the importance of customer orientation. Following the recent economic recession, there are still concerns for the manufacturer and retailer interface; amongst a number of key issues, there is a need to grow confidence. Findings from the pilot consumer survey highlight the need to improve quality, both with the "internal furnishings" and the "external structural frame". Consumers show little concern with waiting time (average 6-8 weeks) for new products, providing the product is of high quality on delivery; "free from so many snags". A third of the consumers questioned are prepared to wait longer than 8 weeks for new products.

Competitor Orientation – Tentative feedback from consumers indicates low levels of importance to brand (only 4/45 participants selecting brand), implying there is a low level of loyalty amongst current caravan owners. The UK industry has for some time, been dominated by two key players together representing 67% of UK caravan sales *(Lynch et al.* 2009), although this figure (2007) is anticipated to be much higher in the current market. Industry participants feel it is important to always "stay one step ahead of the competition".

Inter-functional Coordination – Directors and senior managers interviewed highlighted this as aspect as the most difficult to manage, even more so, during the economic recession. When demand levels are unpredictable, systems and some processes require new ways to adapt, creating greater pressure on individuals. The inter-functional coordination is expected to meet the challenges that are being forced, in the bid to remain market orientated during recessional periods.

DISCUSSION - In addition, the literature evaluation considers if the adoption of a full market orientated approach is the correct response for today's market place to address question 3, leading to a conclusion. *Payne (2001:46)* questions the practicality and reality of being able to change orientation in response to changing market conditions, further highlighting that "most organisations have a range of conflicting orientations and associated attitudes". The pressures to remain efficient in production yet still offer the customer quality, reliability in delivery and service whilst still providing choice, perhaps indicates the scope for a fresh look at the way market orientation is implemented. This leads to a series of questions, shown in table 4, to be presented to the case industry, the UK touring caravan industry.

Measurement - Economic Recovery (Open questions; Likert scale ranking)
Q1. With consideration to the recent economic recession, what do you consider to be **three key** issues facing the UK touring caravan industry?
Q2. Do you consider the UK touring caravan industry to be recovering from the economic recession? (*Tick, circle or highlight one*)
Q2a) If you answered a YES option, for approximately how long did the recession affect your business? (*Tick, circle or highlight one*)

Q2 b) If you answered a NO option, for approximately how long has the recession affected your business? (*Tick, circle or highlight one*) **Q2 c) If you answered NOT APPLICABLE**, why do you think your business has not been affected by the recession?
Measurement - Market orientation (Open questions; ranking) Q3. The exploratory interviews for this research project revealed a common perception, amongst the UK touring caravan industry, that individual manufacturers, suppliers and retailers are market orientated. In conjunction with your business, provide **two reasons** as to how you think this has been achieved. Q4. How would you personally **define** a market orientation? Q5. Please could you identify up to **three benefits** of being market orientated within your business. Q6. Identify up to three issues when trying to adopt a market orientation within your organisation? Q7. Whose responsibility within the organisation is it to ensure your business is market orientated? Q8. How would you personally rate the three above named constructs in order of importance within your organisation? (1 = most important; 3 = least important) Q9. Which of these listed constructs (listed above), do you personally feel requires the most improvement within your organisation? Please briefly explain why and how this should be done. Q10. Which of the three constructs (listed above) do you feel is the most problematic to manage during an economic recession and why?

Table 4: Questions for the industry survey

CONCLUSION

The academic interpretation of a market orientation requires a long term view of customers, competition and perhaps more significantly, this approach requires acceptance that change is ongoing, requiring continuous development. The literature study has shown that a market orientation is necessary, but the issues highlighting inter-functional coordination indicate the Narver and Slater (1990) definition is difficult to implement successfully. This further implies that market orientation, although ideal may not realistically provide the complete panacea for organisations to achieve a sustainable competitive advantage. The literature evaluation leads to the conclusion that a market orientation provides the necessary foundation for competitive advantage, but needs to be further complemented by other orientation cultures. This theory of course will now be fully tested within industry.

REFERENCES

Dean, J (1950) "Pricing policies for new products". Harvard Business Review. Vol. 28 (Nov): 45-53

Deshpande, R and Webster, F (1989) "Organisational culture and marketing: defining the research agenda". Journal of Marketing. Vol. 53 (1): 3-15

Erevelles, S and Stevensson, T (2005) "Enhancing the business to business supply chain: Insights from partitioning the supply side". Industrial Marketing Management. Vol. 35: 481-492

Gatignon, H and Xuereb, J (1997) "Strategic orientation of the firm and new product performance". Journal of Marketing. Vol. 34 (Feb): 77-90

Harris, L and Piercy, N (1997) "market orientation is free: the real costs of becoming market-led". Management Decision. Vol. 31 (1): 33-38

Henderson, S (1998) "No such thing as market orientation – a call for no more papers" Management Decision Vol. 36 (9): 598-609

Kohli, B and Jaworski, A (1990) "Market orientation: The construct, research propositions, and managerial implications". Journal of Marketing. Vol. 54 (April): 1-18

Levitt, (1960) "Marketing Myopia," Harvard Business Review, Vol. 38 (4):45-57

Lynch, J., Mason, R., Beresford, A. and Found, P. (2009) An Exploration of the Supply Chain Design and Organisation of the UK Caravan Manufacturing Industry. 14th International Symposium for Logistics, Istanbul, Turkey, July 2009.

Lynch, J., Mason, R., Beresford, A. and Found, P. (2010) "Rethinking strategic orientations to manage manufacturing supply chains: Applied to the UK touring caravan industry". POMS 21st Annual Conference, Vancouver, May 2010.

Keith, Robert, J (1959) "An interpretation of the marketing concept, American Marketing Association, Chicago, IL

Keith, Robert, J (1960) "The marketing revolution" Journal of Marketing, No. 3 (Jan):35-38

McNamara, C (1972) "The Present Status of the Marketing Concept," Journal of Marketing. (Jan): 50-57

Min, S and Mentzer, J (2000) "The role of marketing in supply chain management", International Journal of Physical Distribution & Logistics Management. Vol.30 (9): 765-787

Narver, J. And Slater, S (1990) The effect of market orientation on business profitability. Journal of Marketing. Vol. 54 (October): pp. 20-35

Ottessen, G and Gronhaug, K (2003) "Exploring the dynamics of market orientation in turbulent environments: a case study". European Journal of marketing. Vol.38 (8): 956-973

Payne, A (2001) "Developing a marketing –orientated organisation". Business Horizons. May-June: 46-53

Pearson, Gordon, J (1993) "Business Orientation: Cliché or Substance?" Journal of Marketing Management. Vol.99 (9): 233-243

Saunders, M., Thornhill, A and Lewis, P (2007) "Research methods for business students". Pearson. Essex

Schurr, S (1949) "Atomic power in selected industries". Harvard Business Review. Vol. 27 (4): 459-479

Shapiro, B (1988) "What the hell is 'market orientated'?" Harvard Business Review. Nov-Dec: 119-125

Slack, N., Chambers, S and Johnston, R (2007) "Operations Management" 5th Edition. Prentice hall

The Caravan Club: Facts, available at: http://www.caravanclub.co.uk/media/803092/corporate%20facts%20brochure.pdf [accessed 28/04/10]

Timms, Stephen. (2007) BERR *Westminster Forum The way Ahead for UK Manufacturing* http://www.berr.gov.uk/pressroom/Speeches/pages42162.html accessed on November 21st 2008

Voss, G and Voss, Z (2000) "Strategic orientation and firm performance in an artistic environment". Journal of Marketing. Vol. 64 (1):67-83

Zhou, K and Li, Caroline (2010) "How strategic orientations influence the building of dynamic capability in emerging economies". Vol. 63:224-231

LICENSING AND INNOVATION IN DIFFERENTIATED MARKETS

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ABSTRACT

This paper examines technology licensing in a differentiated duopoly model in which a research laboratory has a cost reducing technology or a quality improving technology and can license the new technology to one firm producing a low quality product competing with another firm producing a high quality product. The equilibrium licensing contracts under fixed fee and royalty licensing are characterized. We provide conditions under which the patent holding laboratory obtains larger profits under fixed fee licensing of the product innovation than under royalty licensing. We also establish conditions under which the patent holding laboratory earns larger profits under fixed fee licensing of the process innovation than under royalty licensing.

INTRODUCTION

The purpose of this paper is to examine patent licensing contracts in a differentiated duopoly model in which a research laboratory has a cost reducing technology or a quality improving technology and can license the innovation to one firm producing a low quality product competing with another firm producing a high quality product.

There exists a large literature on patent licensing. Kamien and Tauman (1986) examined the issue of fixed fee licensing versus royalty licensing for an innovator who is a non-producer. Katz and Shapiro (1985) studied fixed fee licensing of a cost reducing innovation between firms who undertake Cournot competition in the product market. For the survey of the literature on patent licensing, see Kamien (1992) among others. The existing literature on patent licensing has focused on a single innovation. One exception is Li and Song (2009). Li and Song (2009) study the licensing of product innovation in a differentiated duopoly model in which a firm holding patents of technologies is also a competitor in the product market.

Our paper is different from Li and Song (2009) in three respects. First, in our paper, a patent holding laboratory is a non-producer. Second, Li and Song (2009) consider new and old technologies regarding product innovation, but they do not consider process innovation. We consider both a cost reducing technology and a quality improving technology, that is, both product and process innovation. Third, we examine price competition in the product market while Li and Song (2009) study quantity competition.

We analyze a two-stage game in which in the first stage, the patent holding laboratory decides whether it licenses its product innovation or process innovation to the firm producing the lower quality product and in the second stage, the two firms engage in price competition in the product market.

The main results are as follows. The equilibrium licensing contracts under fixed fee and royalty licensing are characterized. We provide conditions under which the patent holding laboratory obtains larger profits under fixed fee licensing of the product innovation than under royalty licensing. We also establish conditions under which the patent holding laboratory earns larger profits under fixed fee licensing of the process innovation than under royalty licensing.

The paper is organized as follows. Section 2 introduces the model. In Section 3, we analyze licensing a patent for a process innovation. In Section 4, we examine licensing a patent for a product innovation. Section 5 concludes.

MODEL

Let us consider an industry in which two firms produce differentiated products. Two products are differentiated in terms of quality. Let the two firms labeled firm 1 and 2. Let c_i denote firm i's constant unit cost, $i = 1,2$. Suppose that the two products are differentiated in terms of product quality. Let α denote firm 1's product quality and β denote firm 2's product quality. Assume that $\alpha > \beta$. Let p_i denote the price of firm i's product. Consumers are distributed uniformly on the set $\Theta = [0,1] \subset \mathrm{R}$. Let $\theta \in \Theta$. We assume the density function $f(\theta) = 1$ on Θ. Following Tirole (1988), let each consumer's utility be given by

$$U = \begin{cases} \theta S - p & \text{if } \theta S - p > 0, \\ 0 & \text{otherwise,} \end{cases}$$

where S is product quality. Suppose that each consumer purchases one of the two products. Then a consumer $\hat{\theta}$ who is indifferent between purchasing product 1 and product 2 is given by

$$\hat{\theta} = \frac{p_1 - p_2}{\alpha - \beta}.$$

A consumer $\underline{\theta}$ who is indifferent between purchasing product 2 and nothing is given by

$$\underline{\theta} = \frac{p_2}{\beta}.$$

Thus, the demand for product 1 is given by $Q_1 = 1 - \hat{\theta}$ and the demand for product 2 is given by $Q_2 = \hat{\theta} - \underline{\theta}$. That is, the segment $[\hat{\theta}, 1]$ of consumers purchases product 1 and the segment $[\underline{\theta}, \hat{\theta}]$ of consumers buys product 2.

Suppose that a research laboratory holds a patent of a cost reducing technology or a patent of a quality improving technology. By getting the license of the cost reducing technology, firm 2, the licensee, can reduce its cost from $c_2 > 0$ to zero. By obtaining the license of the quality improving technology, firm 2 can increase its product quality from β to ω , $\omega > \beta$. We consider two cases: $\alpha > \omega$ and $\omega > \alpha$.

The game we consider has two stages. At the first stage, the patent holding laboratory decides whether or not it licenses its product innovation or process innovation to firm 2 and in the second stage, the two firms engage in price competition in the product market. We examine fixed fee contracts and royalty contracts. For simplicity, we assume that $c_1 = 0$.

We solve the game backwards. At the second stage, each firm determines the price of its product simultaneously.

Firm 1's profits is given as

$$\Pi_1 = (p_1 - c_1)Q_1.$$

Firm 2's profits is given as

$$\Pi_2 = (p_1 - c_2)Q_2.$$

Then the equilibrium prices satisfy

$$p_1^* = \frac{2\alpha(\alpha-\beta)+\alpha c_2}{4\alpha-\beta}$$

and

$$p_2^* - c_2 = \frac{\beta(\alpha-\beta)-(2\alpha-\beta)c_2}{4\alpha-\beta}.$$

Hence the equilibrium quantities are

$$Q_1^* = \frac{2\alpha(\alpha-\beta)+\alpha c_2}{(\alpha-\beta)(4\alpha-\beta)}$$

and

$$Q_2^* = \frac{\alpha\beta(\alpha-\beta)-\alpha(2\alpha-\beta)c_2}{\beta(\alpha-\beta)(4\alpha-\beta)}.$$

PRODUCT INNOVATION

Assume that firm 1's product quality is α and firm 2's product quality is β. Firm 2 can obtain the product with quality $\omega > \beta$ by getting the license from the research laboratory. First, we consider the case of $\alpha > \omega$. In this section, we assume that $c_2 = 0$. Thus the two firms' unit costs are zero.

Under the fixed fee contract, the research laboratory's problem can be written as

$$\max F^q$$

subject to

$$\Pi_2(\alpha,\omega) - F^q \geq \Pi_2(\alpha,\beta).$$

Then the equilibrium fixed fee contract F^{q*} is

$$F^{q*} = \frac{\alpha\omega(\alpha-\omega)}{(4\alpha-\omega)^2} - \frac{\alpha\beta(\alpha-\beta)}{(4\alpha-\beta)^2}.$$

Let r^q denote a royalty rate. Under the royalty contract, the research laboratory's problem can be written as

$$\max r^q \cdot Q_2$$

subject to

$$\Pi_2(\alpha,\omega) - r^q Q_2 \geq \Pi_2(\alpha,\beta).$$

Note that we have

$$Q_2 = \frac{\alpha}{4\alpha-\omega} - \frac{\alpha(2\alpha-\omega)}{(4\alpha-\omega)(\alpha-\omega)\omega} \cdot r^q.$$

Thus, the equilibrium royalty is

$$r^{q*} = \frac{\omega(\alpha - \omega)}{2(2\alpha - \omega)}$$

and the laboratory's revenue is

$$r^{q*}Q_2^* = \frac{\alpha\omega(\alpha - \omega)}{4(4\alpha - \omega)(2\alpha - \omega)}.$$

Hence the fixed fee contract is chosen if

$$\frac{\alpha\omega(\alpha - \omega)(4\alpha - 3\omega)}{4(4\alpha - \omega)^2(2\alpha - \omega)} > \frac{\alpha\beta(\alpha - \beta)}{(4\alpha - \beta)^2}.$$

Next we examine the case of $\omega > \alpha$. In this case, firm 2 becomes the producer of the higher quality product. Under the fixed fee contract, the research laboratory's problem can be written as

$$\max F^q$$

subject to

$$\Pi_2(\alpha, \omega) - F^q \geq \Pi_2(\alpha, \beta).$$

Thus, the equilibrium fixed fee contract F^{q**} is

$$F^{q**} = \frac{4\omega^2(\omega - \alpha)}{(4\omega - \alpha)^2} - \frac{\alpha\beta(\alpha - \beta)}{(4\alpha - \beta)^2}.$$

Under the royalty contract, the research laboratory's problem can be written as

$$\max r^q \cdot Q_2$$

subject to

$$\Pi_2(\alpha, \omega) - r^q Q_2 \geq \Pi_2(\alpha, \beta).$$

Note that we have

$$Q_2^{**} = \frac{2\omega}{4\omega - \alpha} - \frac{2\omega - \alpha}{(4\omega - \alpha)(\omega - \alpha)} \cdot r^q.$$

Thus, the equilibrium royalty rate is

$$r^{q**} = \frac{\omega(\omega - \alpha)}{(2\omega - \alpha)}$$

and the laboratory's revenue is

$$r^{q**}Q_2^{**} = \frac{\omega^2(\omega - \alpha)}{(4\omega - \alpha)(2\omega - \alpha)}.$$

Therefore the fixed fee contract is chosen if

$$\frac{\omega^2(\omega-\alpha)(4\omega-3\alpha)}{(4\omega-\alpha)^2(2\omega-\alpha)} > \frac{\alpha\beta(\alpha-\beta)}{(4\alpha-\beta)^2}.$$

PROCESS INNOVATION

Assume that firm 1's product quality is α and firm 2's product quality is β. Recall that $c_1 = 0$ and $c_2 > 0$. Under the fixed fee contract, the research laboratory's problem can be written as

$$\max F^c$$

subject to

$$\Pi_2(c=0) - F^c \geq \Pi_2(c_2).$$

Thus, the equilibrium fixed fee contract is

$$\begin{aligned} F^{c*} &= \frac{\alpha\beta(\alpha-\beta)}{(4\alpha-\beta)^2} \\ &\quad - \frac{\beta(\alpha-\beta)-(2\alpha-\beta)c_2}{(4\alpha-\beta)^2}\{\alpha - \frac{\alpha(2\alpha-\beta)c_2}{\beta(\alpha-\beta)}\} \\ &= \frac{2\alpha(2\alpha-\beta)c_2}{(4\alpha-\beta)^2} - \frac{\alpha(2\alpha-\beta)^2 c_2}{(4\alpha-\beta)^2\beta(\alpha-\beta)}. \end{aligned}$$

Under the royalty contract, the research laboratory's problem can be written as

$$\max r^c \cdot Q_2^c$$

subject to

$$r^c \leq c_2$$

$$\Pi_2(r^c) - r^c Q_2^c \geq \Pi_2(c_2).$$

Note that we have

$$Q_2^{c*} = \frac{\alpha}{4\alpha-\beta} - \frac{\alpha(2\alpha-\beta)}{(4\alpha-\beta)(\alpha-\beta)\beta} \cdot r^c.$$

Thus, the equilibrium royalty contract is

$$r^{c*} = \frac{\beta(\alpha-\beta)}{2(2\alpha-\beta)}.$$

Hence $r^{c*}Q_2^{c*} = \dfrac{\alpha\beta(\alpha-\beta)}{4(4\alpha-\beta)(2\alpha-\beta)}$.

Suppose that the constraint $r \leq c_2$ binds at the equilibrium. That is,

$$r^{c*} = c_2.$$

Then

$$F^{c*} - r^{c*}Q_2^{c*}$$
$$= \frac{\alpha\beta(\alpha-\beta)^2}{2(4\alpha-\beta)^2(2\alpha-\beta)} > 0.$$

Thus, the patent holding laboratory will choose the fixed fee contract.

CONCLUSION

This paper has studied contracts of licensing cost reducing and quality improving technologies developed by a research laboratory in a model in which two firms compete in a differentiated market. We have characterized the equilibrium licensing contracts under fixed fees and royalties. We have provided conditions under which the patent holding laboratory obtains larger revenue by licensing the product innovation under the fixed fee contract than under the royalty contract. We have also established conditions under which the patent holding laboratory earns larger revenue by licensing the process innovation under the fixed fee contract than under the royalty contract.

Base on the results in this study, we could argue about designing policies regarding firms' R&D. For instance, consider an industry in which a domestic firm producing a low quality product competes with a foreign firm producing a high quality product in the home country. Then the results in this paper would suggest that a government in the home country can support an R&D of a research laboratory through subsidies and help domestic firms to produce a superior product or to reduce their production costs by licensing the innovation.

REFERENCES

Kamien, M. (1992);"Patent licensing,"in *Handbook of Game Theor*y, Vol. 1, R. Aumann and S. Hart, Eds. Amsterdam: North Holland.

Kamien, M. and Y. Tauman (1986);"Fees versus royalties and the private value of a patent,"*Quarterly Journal of Economics*, vol. 101, 471-491.

Katz, M. and C. Shapiro (1985);"On the licensing of innovations," *Rand Journal of Economics*, vol. 16, 504-520.

Li, C. and J. Song (2009);"Technology licensing in a vertically differentiated duopoly," *Japan and the World Economy*, vol. 21, 183-190.

Tirole, J. (1988); *Theory of Industrial Organization*, Mass, The MIT Press.

FLY TIPPING ENFORCEMENT: A UK LOCAL AUTHORITY SERVICE SUPPLY CHAIN DESIGN PROBLEM

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INTRODUCTION

Local authorities in the UK are the administrative units of local government. They are responsible for providing a portfolio of public services areas that include Education, Housing, Health & Social Care and Environment & Planning Services. Logistics plays a particularly important role in the Environment & Planning Services area as rubbish & waste collection, recycling, highways maintenance and road gritting are all part of this service's remit. These are all high profile and topical issues in the UK, with media attention increasing public expectation of public service provision in terms of criteria such as availability, responsiveness, choice and flexibility. This was witnessed by the widely expressed 'outrage' in the press at the salt shortages for road gritting during January and February this year. This heightening of customer expectation has coincided with a period of increasing budget and resource austerity to form a 'double whammy' effect for the public sector. This situation is only likely to compound following the UK General Election in May 2010, as all the major political parties promise to constrain public sector spending and release billions of pounds of cost savings from public sector waste elimination initiatives. In such a climate effective and efficient internal process and supply chain design takes on an added importance.

The purpose of this paper is to provide a **case study** of a supply chain design within the Environment & Planning Services portfolio at a UK local authority called Torfaen County Borough Council (TCBC). The supply chain in question involves the material and information flows associated with the location, disposal and enforcement (prosecution) of 'fly-tipping'. *Fly-tipping* is the illegal disposal of waste on any non-private land other than an authorised landfill site, which usually occurs at night in remote but easily accessible locations. This is an important local authority issue as it costs an estimated £500 per ton to clean up. It is also very high on the list of concerns of local residents in their periodic Police and Community Team (PACT) meetings. It should be pointed out that this is <u>not</u> a research paper. It is a case study that <u>describes</u> the current service supply chain design and its associated problems, and was produced as an output of a Strategic Insight Programme (SIP) project that acted as a pre-diagnostic to a future project. The next phase will be to actually intervene and redesign the chain and internal processes to realise significant performance improvement.

Fly-tipping is an unusual supply chain scenario that presents challenges for the application of contemporary 'best practice' process-improvement thinking. It is therefore hoped that this case will prove of interesting. However, the main reason for presenting this case study at the conference is to solicit input from the collective experience and wisdom of the ISL participants in order to factor this into the subsequent intervention project ('many minds is better than one!')

LITERATURE

The double whammy scenario summarised in the previous section is familiar to much of the private-sector. Here, for many years, organisations and their supply chains have sought in the face of increasingly intense levels of competition to simultaneously improve quality and responsiveness to [increasing] customer demands whilst simultaneously reducing costs. This competitive climate has given birth since the 1980s to a number of influential *contemporary process improvement paradigms* that originated within the operations, logistics and supply chain management disciplines. These notably, but not comprehensively, include Lean Thinking (Womack *et al*., 1990; Womack and Jones, 1996), Theory of Constraints (Goldratt and Cox, 1993), Six Sigma (Harry, 1988), Agility (Christopher *et al*., 1999) and Systems Dynamics (Forrester, 1961; Burbidge, 1983; Towill, 1999).

Such paradigms seem to be diffusing increasingly into public sector projects within the UK, which is unsurprising given the nature of the issues facing this sector and the promise of 'do more and better with less' that the adherents of these paradigms promote. This diffusion pattern is particularly true of Lean. However, apart from natural conservatism in the face of change, the Lean paradigm in particular has drawn often vitriolic criticism when it has been applied to service and public sector applications (see Seddon, 2005). These criticisms have centred around two issues (1) <u>Inappropriate Design</u>: Lean, like the other paradigms listed above, originated within the manufacturing sector. Manufacturing differs substantively from service/ public sector, so Lean 'doesn't fit properly.' (2) <u>Inappropriate Implementation</u>: Lean implementations tend to amount to no more than the application of one or more of the tools (such as 5S, takt time or poke-yoke) in its rich toolkit.

This dissatisfaction has given rise to a new contemporary paradigm entitled *Systems Thinking* (ST) that has been developed specifically for application within the service and public sectors. Drawing extensively on the work of Deming (1988), ST makes a significant contribution in the way that it conceives *failure-demand* (demand on the resources of an organisation caused by its own failures) and explains the sub-optimalising effects of government targets and 'choice' on public sector operations. ST also stresses that all service operations differ notably from manufacturing in terms of their variety of demand and customer involvement in the 'production' process (see Seddon, 2003; 2005; 2008). ST consequently focuses on understanding the precise nature of demand, and on changing the system conditions and managerial mindset (*op cit*.).

Viewed dispassionately, all of the contemporary process improvement paradigms mentioned above have more in common than in difference. Any differences seems to be merely of emphasis. They are all presented by their proponents as an antidote to the local rationality (reductionism), task fragmentation, inter-functional hand-off and scale-derived efficiency that are the feature of Scientific Management (Taylor, 1911). Likewise, they all stress the need to adopt a systems perspective, capture the customer conception of 'value' and maximise the velocity of the flow of work through the whole system (lead time compression) in response to a customer-dictated pull signal; usually facilitated by autonomous, self managing work groups.

However, ST has in turn drawn substantive criticisms from academics and practitioners on its application within the public sector. These criticisms notably include its opaque and evasive position on capacity, and an absolute and impractical position on the issue of standardisation and standard working practices. This state of affairs leaves no unmitigated guidance for the construction of effective design process principles for the public sector, such as the Fly Tipping Enforcement process detailed in this case study.

DATA COLLECTION

The fieldwork reported upon in this paper was the product of a collaborative project between TCBC and Newport Business School (NBS). It was funded under the Welsh Assembly Government's Strategic Insight Programme (SIP), which was designed to stimulate the building of relationships between academia and practitioners. The actual fieldwork involved approximately 50 hours of data collection during November-December 2009 with ten TCBC members of staff drawn from four echelons of the Fly-Tipping Enforcement supply chain.

Data collection techniques included semi and unstructured interviews, participant observation, photographs and the collection and analysis of all standard documents used in this process. Whilst the terms of the SIP funding did not permit the undertaking of actual research, the authors summarised the above data into a Final Report that was provided to TCBC on completion of the project. This document contained a simple 'map' of the Fly-Tipping Enforcement process and a series of tables detailing all of the issues (problems and improvement opportunities) both witnessed and reported during the exercise. Each issue was given a unique identifying code that was plotted onto the map for cross-reference purposes. It was the frequency and nature of these issues that prompted discussion of a follow-on, intervention (improvement) project.

CASE DISCUSSION

Torfaen County Borough Council

Torfaen County Borough Council (TCBC) is one of 22 unitary authority areas in the Wales; responsible for the provision of all local government services. These services are broken down into the service areas listed in the Introduction. TCBC is divided in 24 electoral wards and returns 44 councillors. It encompasses a population of 91,000 within an area of 126 km^2 in South East Wales.

The northern half of this area is predominantly rural, whilst the southern half is urban and centred on the town of Cwmbran. Its administrative centre is in Pontypool, which is in the centre of the borough. However, most of the administration is conducted from the Civic Centre at the County Hall in Cwmbran, which is shared with Monmouthshire County Council.

Fly-Tipping in Context

According to the Environment Agency, fly-tipping amounts to more than one 'black bin-bags-worth' (bbw) of waste and can result in prosecution and a criminal record. Anything less than this amount of dumped waste is classified as *littering,* is subject to different legislation and cannot result in prosecution. The UK Westminster government sets targets and publishes league tables of local authority fly-tipping performance via the Environment Agency's *Fly-Capture* computer system. Performance is measured against a five-day leadtime to pickup and dispose of fly-tipped waste from the date when the incident was reported.

Like a speeding fine, the fly-tipping prosecution process has a six month window within which a prosecution must be brought, after which it becomes invalid. There are six fly-tipping *waste streams* (1) Household waste – such as black bin bags (2) Larger household items – such as settees, beds and fridges (3) DIY waste – such as old fireplaces or baths (4) Builders' waste – such as rubble (5) Commercial waste – such as incorrectly disposed tyres (6) Abandoned cars. This latter fly-tipping waste stream is handled as a separate process at TCBC.

The volume of waste in number of these streams is predictable. For example, the volume of fly-tipped household waste increased significantly with the introduction of a bi-weekly home wheelie-bin refuse collection system when it was introduced in 2006, which was compounded by a draconian approach to *sidewaste* (anything left by the side of the wheelie-bin for collection because it wouldn't fit inside because there was no space) – which was left kerbside and immediately classified as fly-tipping!

Likewise, the amount of fly-tipped large household items increased significantly when the council introduced a £15 charge for their pickup and removal (incidentally, subsequent analysis established that it actually costs them more than £15 just to process the cheque)! Fly-tipped DIY and builders' waste also increased when a £35 charge was introduced for disposing of such waste at a civic amenity site; whilst the number of abandoned cars is highly correlated with scrap metal market values.

TCBC fly-tipping enforcement teams have introduced a number of proactive measures. For example, in 2008 they established a database of all car mechanic and other firms in the borough who receive old car tyres. They visited all of these and as a consequence reduced the number of fly-tipped tyres in the period. Likewise, they funded (from fines) and installed a number of *gypsy gates* to physically prevent access to a number of know fly-tipping hotspots. However, all this achieved was to move the problem elsewhere in the borough.

Fly-Tipping Enforcement Process
A simple schematic representation of the main entities involved in the TCBC Fly-Tipping Enforcement process is presented in Figure 1. The design of this process currently separates front and back-office operations in the belief that a 'service factory' and its concomitant efficiencies can be achieved from scale and specialisation (after Seddon, 2008). The *front-office* is the part of the process that deals directly with the customer. Within TCBC this is the term used to describe a small telephone call centre entitled *Call Torfaen* that is physically located in Pontypool. There are six members of this team, although three additional Receptionists at various Civic Centres in the borough also form extra capacity during busy periods.

All calls to Call Torfaen are [supposedly] made by the general public on a dedicated telephone number. Approximately 5% of these calls concern fly-tipping. Of the other work streams that make up the remainder of its workload 70% are for benefits and council tax payments, 10% are related to refuse collection and the balance concern payments for various council services and housing & rent arrears calls regarding its housing stock. The actual call centre telephony management system is called WITNESS. Integral to this is a highly visual real-time display of cumulative daily operational performance for Call Torfaen in the guise of the cumulative number of calls processed, work in progress calls, number of calls waiting in the queue and the number of abandoned calls.

This latter category is the overriding concern for the centre. When a fly-tipping call is received via WITNESS, the operator interacts with two other stand-alone IT systems. The first is called HEAT, into which the full telephone, address and details of the fly-tipping incident (description, physical location etc) must be entered. HEAT then provides the operator with the historical details of all contact for all of TCBC's services for the address of that caller. These details must then be cut and pasted by the operator into an IT system called MAYRISE. This is the main conduit between the font and back-office operations.

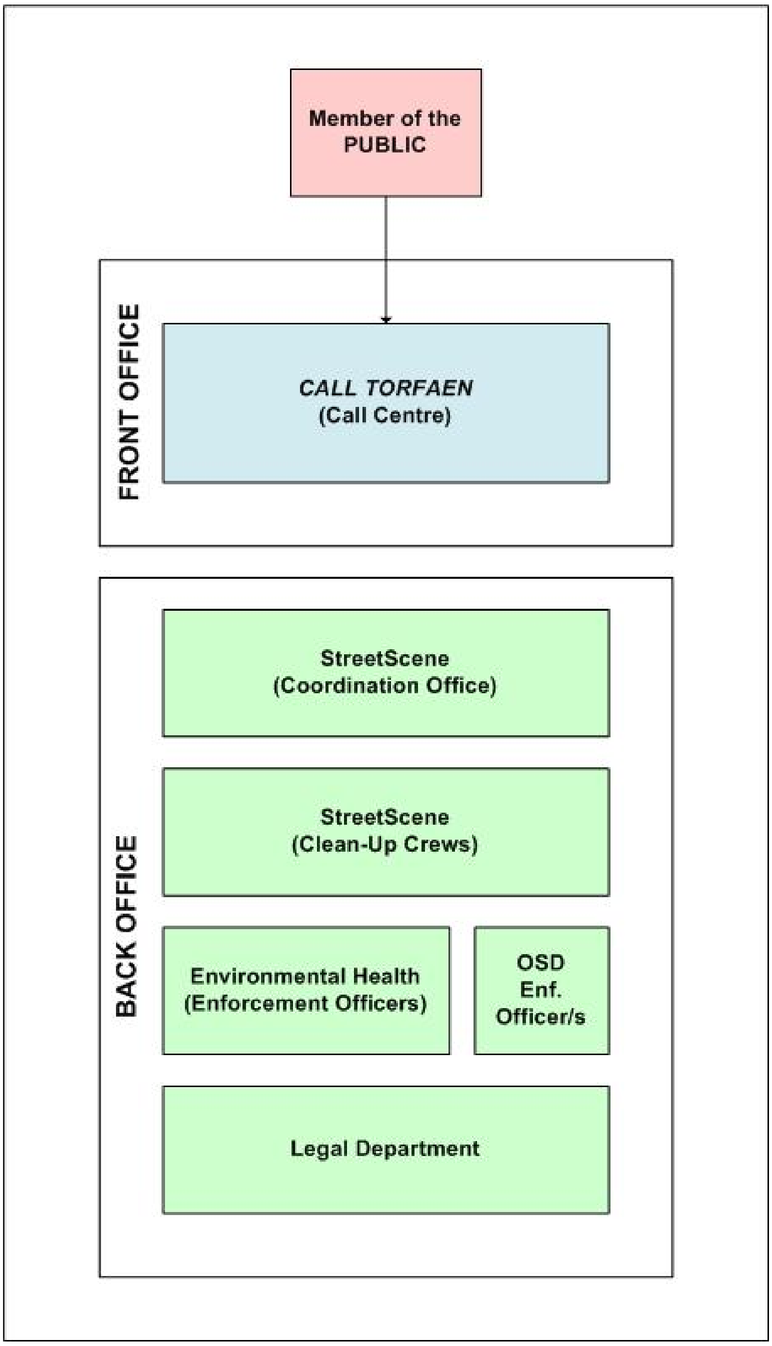
The first part of the *back-office* operations is called StreetScene, which is based at a depot in New Inn near Pontypool and reports to the Head of the Operational Service Division (OSD). Fly-tipping clean-up is only a small part of StreetScene's portfolio of activities that include cemeteries & burials; street cleansing; grass, hedge & shrub maintenance; forestry; parks & open spaces and horticulture for sponsored roundabouts. StreetScene has no involvement in Refuse & Recycling. After Call Torfaen enter the details of a fly-tipping incident into MAYRISE, it results in a job ticket being printed at the StreetScene Office the next day.

As soon as this happens the "clock starts ticking" in terms of the government's statutory five-day clean-up target. The Coordinating Officer checks the reported location on the job ticket against a computer-based map system (PLANWEB) to confirm that it is council-owned land. At the end of each day she drives to the reported job ticket sites and documents the type, quantity and exact location of the fly-tipped waste onto a Record Sheet (although this only happens for 40% of jobs). The next day she prioritises the sequence and workload of jobs in the form of Job Ticket/ Record Sheet paperwork pack, and hands these out to the StreetScene Clean-Up Crews.

There are two crews, each of two men in a 3.5t flatbed truck. There is one for the rural north of the borough and one for the urbanised south (the demarcation line being the New Inn depot in the centre of the borough). These are supposedly dedicated for fly-tipping. However, they are also called upon to clean-up syringes, blood (after road traffic accidents), animal carcases and dog mess. Because of the variability in their workload they spend much time touring between known fly-tipping 'hotspots'. If they notice any fly-tipped waste in-transit, they stop and clear it up on the spot.

There are approximately 20 hotspots in each half of the borough; widely dispersed. It is not unusual to find as much as 6.0t of rubbish dumped overnight at a hot spot. Each truck is capable of transporting a 1.0t load, and it takes on average 45 minutes to travel to the civic amenity (dump) site, also at New Inn, and return to the hotspot. After completing a job the crew return to the StreetScene Office to return the completed job ticket. These tickets are then batched before being manually typed into another IT system called FLY-CAPTURE, which is uploaded on a monthly basis to the Environment Agency. It is this data that forms for formal monitoring and control of fly-tipping UK wide.

Figure 1. Fly-tipping enforcement: front and back-office departments/ agents



When a StreetScene crew attend a fly-tipping incident and encounter waste that might reveal the identity of the perpetrator, such as black bin bags, they are supposed to investigate. This means rummaging around in the waste to find the type of evidence that contains a name, address or photograph (such as correspondence or bank statements). If they find such evidence they are then meant to call the Environmental Health (Enforcement) Team. When a member of this team arrives, they will photograph the scene to establish extent and context of the incident (eg there are seven bagsworth and its at a beauty spot), list the significant items found at the site and take away the identifying evidence. This forms the basis for the case file.

The Environmental Health Team is based in Cwmbran and reports to the Head of Public Protection. There are seven Environmental Health officers, of which only three deal with fly-tipping (the Enforcement Officers). Fly-tipping accounts for 5-10% of the workload of the latter group.

The other activities of all these officers includes noise nuisance, household issues (eg damp), public health (eg blocked drains and dog fouling) and the inspection and licensing of commercial premises such as restaurants. There is also a single vestigial OSD Enforcement Officer based at New Inn who reports to the Head of OSD. The Enforcement team use a different, standalone IT system called FLARE for their activity logging and work management. Therefore, when a job is passed from StreetScene to Enforcement, the details must be manually re-typed into the FLARE system to ensure it can be processed.

A home visit to the identified perpetrator's address is then conducted. For reasons of personal security, Enforcement Officers must do this in pairs. This causes obvious logistical difficulties when one of those is the OSD Enforcement Officer. If the perpetrator is at home they are cautioned according to the Police and Criminal Evidence (PACE) Act 1984. If they are not at home they are left a card giving them 14 days to attend a PACE interview as above.

If the incident involved less than five bbw of waste and does not involve a commercial concern, the Enforcement Team offer the perpetrator an opportunity to pay a £75 fixed penalty notice under the 2005 Clean Neighbourhood Act. Otherwise, or if this option is rejected, the team will progress the case to the Legal department for public prosecution. If successfully prosecuted (within the six month period from the date of the fly-tipping incident), the perpetrator will be forced to pay a fine and will receive a criminal record. In the preceding twelve months, only three cases had progressed as far as the Legal department.

They had dropped all three without proceeding to court on the basis of risk/ insufficient evidence. This was to a large degree a function of 'trigger threshold'. Whilst the law considers 1bbw to be fly-tipping, Enforcement will generally attempt to prosecute only if 5+ bbw; but the Legal department's threshold seems to be an [unarticulated] higher order figure again – in order to pre-empt the Magistrate's 'threshold' and hence reduce the risk of the case being rejected. This is a threshold amplification effect that seems to have portents of Forrester's (1958; 1961) demand amplification effect!

Major Issues
Eighty separate issues were identified by the participants during the course of the SIP project. These were plotted onto a map of the Fly-Tipping Enforcement Process to help establish a number of themes.

Space constraints prohibit a detailed discussion of these. However, the most important four themes can be summarised as:

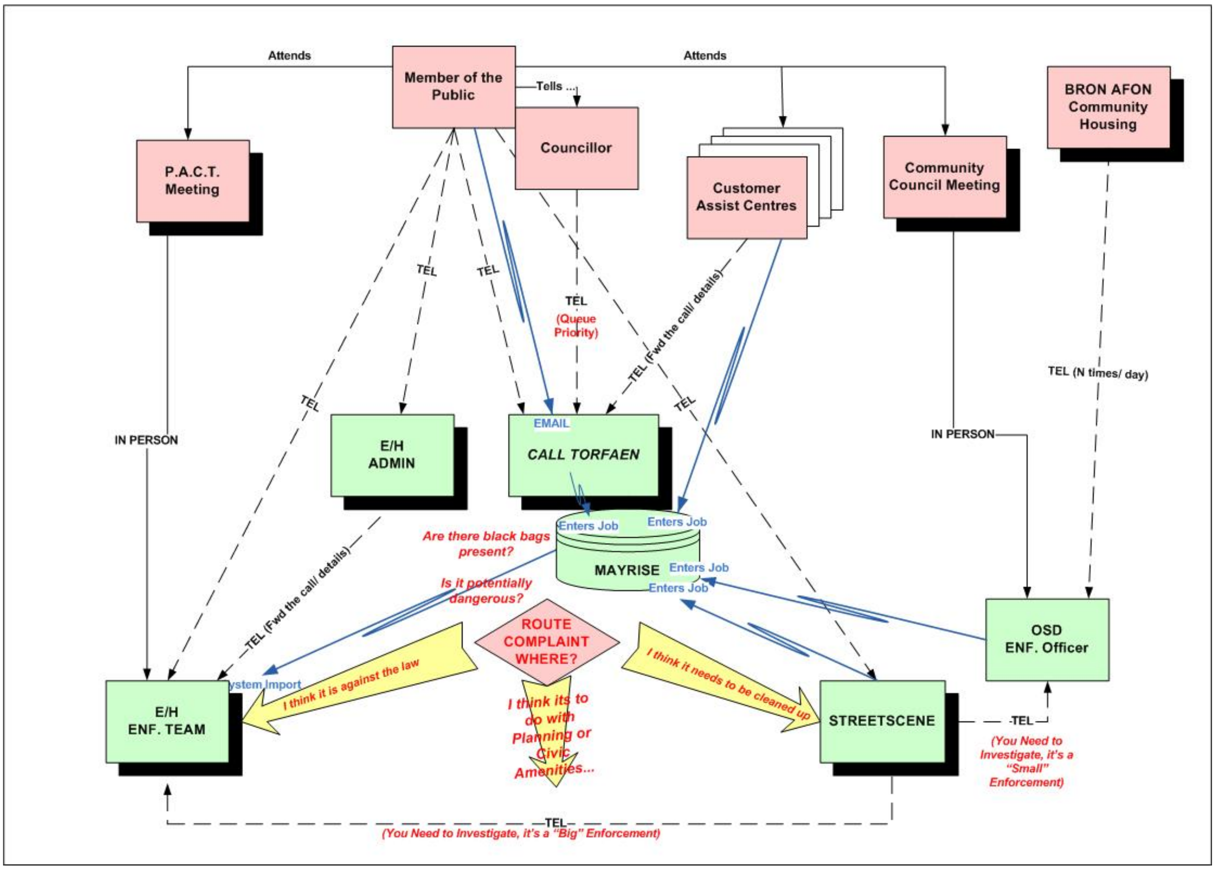
(a) the confusing and overly complex means for the public to register fly-tipping complaints; three separate telephone numbers and four separate email addresses – see Figure 2.

(b) Inappropriate routing of information to the relevant department for initial response – StreetScene or Enforcement?

(c) Proliferation and lack of interoperability of IT systems

(d) Misalignment of different supply chain echelons and their constituent agents - not just performance measurement, but also threshold criteria for stimulating a response.

Figure 2. An overly-complex and 'fuzzy' front-end office operation



CONCLUSIONS AND FUTURE RESEARCH

Given the nature and degree of the issues discussed above, this current service supply chain design was assessed by the participants in this SIP project to be inefficient, unresponsive and ultimately ineffective as it yields neither a high prosecution success rate nor [more aptly] lower incidence of fly-tipping within the borough. There is consequently a significant opportunity for process and supply chain improvement here.

When reflecting upon fly-tipping it is clear that it is an unwinnable battle. It is not realistic to ever expect a minimum of zero incidence; the plain truth is that in a borough of the size and profile of Torfaen there will always be some people who are too lazy, slovenly or stingy due to the variation in human nature to dispose of their waste in a responsible manner. The outcomes of prevention initiatives such as Gypsy-Gates illustrates this issue only so well. Fly-tipping then is akin to a *mess* rather than a solvable problem (after Checkland, 1981). The goal of any intervention in this area will therefore be to alleviate this mess rather than resolve it; to use the available resources and capacity in the most efficient manner possible whilst reducing fly-tipping incidence and volume.

These problem characteristics are removed at some distance from, and raise big issues for, an intervention project based on Lean principles (Womack & Jones 1996). In Lean, the first guiding principle is customer value maximisation (*op cit*.). The fly-tipping problem is instead one of incidence *minimisation*. The cup is half empty rather than half full! An alternative paradigm is therefore required in order to provide guiding principles in such a scenario. The lead contender is surely Systems Thinking. However, the Literature Review established some of the limitations of this paradigm, and reference to the case studies in his books reveals that most too are maximisation problems (see Seddon, 2003; 2008). Yes, Seddon's call to better understand as a first step the real nature of customer demand will be useful here. However, its limitation in the area of capacity management were documented above. What seems to be needed for such [public sector] 'minimisation scenarios' is a new hybrid approach that is capable of generating appropriate service process and supply chain design principles. At the time of writing, TCBC and NBS are in the process of scoping an applied research project that will attempt to achieve this aim. This project will apply Systems, Lean and Theory of Constraints principles to the fly-tipping and other environment & planning services with the goal of realising significant service level and efficiency improvements.

REFERENCES

Burbidge, J.L. (1983). Five golden rules to avoid bankruptcy, *Production Engineer,* Vol.62 (10), pp.13-14.

Checkland, P. (1981). *Systems Thinking, Systems Practice,* John Wiley & Sons: London.

Christopher, M., Harrison, A. and Van Hoek, R. (1999). Creating the agile supply chain: issues and challenges, *Proceedings of the 3rd International Symposium on Logistics,* Florence, Italy.

Deming, W.E. (1988). *Out of Crisis,* Cambridge University Press: Cambridge.

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

Goldratt, E.M. and Cox, J. (1993). *The Goal,* 2nd edition, Gower: Aldershot.

Harry, M.J. (1988). *The Nature of Six Sigma Quality*, Motorola University: Rolling Meadows, Illinois.

Schmenner, R.W. and Swink, M.L. (1998). On theory in operations management, *Journal of Operations Management,* Vol.17, pp.97-113.

Seddon, J. (2003). *Freedom from Command and Control: A Better Way to Make the Work Work,* Vanguard Consulting Ltd: Buckingham.

Seddon, J. (2005). *Watch out for the Toolheads! Everything You Need to Know About Lean Manufacturing Tools and Why They Don't Work in Service Organisations,* Vanguard Education, January, www.lean-service.com.

Seddon, J. (2008). *Systems Thinking in the Public Sector: The Failure of the Reform Regime … A Manifesto for a Better Way,* Triarchy Press: Buckingham.

Taylor, F.W. (1911). *The Principles of Scientific Management,* Harper & Row: New York.

Towill, D.R. (1999). Simplicity wins: twelve rules for designing effective supply chains, *Control,* March, pp.9-13.

Womack, J.P., Jones, D.T. and Roos, D. (1990). *The Machine That Changed the World,* Simon & Schuster: New York.

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

THE EMERGENCE OF SUPPLY CHAIN ECO-SYSTEMS
A SOCIAL NETWORK ANALYSIS (SNA) PERSPECTIVE

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INTRODUCTION

So-called Developed Economies are characterised, if not defined by, specialisation. Indeed the principle of specialisation is evident from the moment one moves from subsistence activity and begins to specialise in an area of comparative advantage. Thus specialisation is fundamental to the evolution of supply chains. We consider the supply chain as a network of specialist actors that interact to deliver goods and services to end-consumers.

The 'eco-system' analogy has become increasingly popular over recent years as scholars have studied the impact of specialisation and in particular various interdependencies that emerge (Dervitsiotis, 2008; Simichi-Levi, *et al*. 2008). Social Network Analysis (SNA) is a dynamic approach that focuses attention on network interdependencies and emphasises the impact of network design on firm competitiveness. However, little attention has been given to the use of SNA in supply chain analysis, with some exceptions such as Lazzarini, *et al*. (2001). The aim of this paper is to investigate the usefulness of SNA in supply chain analysis. The paper is set out as follows: firstly, given that SNA is a new approach for many if us in the SCM field, we provide a brief introduction to SNA; secondly, we present the SNA research design that informed our study; building on this we outline our methodology in the next section; this is followed by a section on findings, these are illustrative of the use of SNA in providing insight into the rather intangible nature of supply chain network relations; and, finally we put forward some conclusions and highlight limitations of our study.

SOCIAL NETWORK ANALYSIS

Social Network Analysis (SNA) is a relatively new, but rapidly growing, field in sociological and economic research. Although its precursors may be traced to Simmel's studies of dyads and triads (Simmel, 1908), it has come to prominence and wide utility only since the 1980's with the advent of powerful computational and computer visualization techniques. This software enables us to develop, analyse and compare quantitative descriptors and visual depictions of the network structures created by social and economic interaction. Most significantly Social Network Analysis provides a "fundamentally different perspective" (Marin and Wellman, 2010) on socio-economic activity, because it is concerned both with a different type of data – relational data – and because it considers the resulting structures and sub-structures (what Simmel called "forms") as the "primary building blocks of the social world" (Marin and Wellman 2010).

Excellent field surveys, together with detailed accounts of techniques and applications, can be found for example in the books by Scott (Scott, 2000) and Wasserman and Faust (Wasserman and Faust, 1994), the collections edited by Carrington et al. (Carrington, Scott, and Wasserman 2005; Carrington and Scott 2010), and the journal edition edited by Van Duijn and Vermunt (2006).

Lazzarini, et al. (2001) suggest that one way to integrate Supply Chain Analysis (SCA) and SNA is to consider simultaneously all type of interdependencies that occur in a given inter-organisational setting. They identify three categories of interdependencies: (a) pooled interdependencies involve discrete or autonomous contributions by loosely coupled actors; (b) sequential interdependencies such as supply chain vertical linkages and associated buyer-seller interdependencies; and (c) reciprocal interdependencies meaning that one actor's input is another actor's output, these actors generally are tightly coupled in that the knowledge of one strongly depends on the knowledge of another.

RESEARCH DESIGN FOR SOCIAL NETWORK ANALYSIS

Five key elements are evident in research design for Social Network Analysis: the choice of sampling units; the form of relations; the relational content; the level of data analysis; and the network boundary (Knoke and Kuklinski 1996:14).

The sampling unit refers both to the "higher-level system whose network is to be investigated" and also "one or more lower-level units" that constitute the nodes or actors in the network. In our case we selected one business networks within a particular rural area, with firms (including: first tier suppliers, manufacturers, retailers and service providers) as nodes.

Knoke & Kuklinski (1996) distinguish between "relational content" and "relational form". Content is the nature of the relationship, e.g. supplier, customer, advisor; and form captures properties of the relations between pairs of actors e.g. frequency, value, reciprocation. They note that the relational content that the researcher chooses to study is usually based on theoretical considerations, and also that each relational content can be viewed as determining a separate network, although some studies may consider multiple types of relations (a "multiplex network"). Within their "typology of relational content" we are interested primarily in "transaction relations" and "communication relations", while acknowledging that there may also be "embedding" in, for example, "sentiment" or "kinship" relations.

The "level of analysis" describes the type of network study: egocentric, dyadic; triadic or complete. We use both "ego" and "complete" network analyses. We note that visual depictions of such networks have long been used in geographic studies to show the spatial structure of trade networks (e.g. Braudel 1982) and, more recently, GIS-based representations of the spatial dimension of these networks have become almost a commonplace.

The nature of such position or patterns of relations can be summarised by analytic measures that range from simple measures of overall network density, to measures of an actor's centrality (or conversely, peripherality) and on to structural measures of subgroups ("cliques"), and comparative measures of structural equivalence in sub-networks or between networks.

Boundary specification is a defining issue for any empirical network research. An influential paper on this topic by Laumann et al (1983) distinguished between a *realist* specification in which the researcher accepts the network boundaries experienced by the actors in the network, and a *nominalist* specification in which the closure of the network is imposed by the researcher's theoretical framework.

In our research we take a position that is something of a hybrid between these two. In general, because at the highest level of our study we are interested in phenomena at the "area" and "sectoral" level, we adopt *nominalist* boundary specifications, i.e. we confine our networks to a geographic area and to a business sector. We do not, however, seek to identify all or a "representative sample" of businesses in that sector or geographic area and to then uncover their network ties. Rather we select an initial set of actors, using qualitative "purposive sampling". We then use Doreian and Woodward's (1992) "expanding-selection" method of data-collection - which results in a "realist" boundary-specification. Thus we terminate our traversal of the emerging network when we encounter an actor who is located outside the geographic area or an economic sector on which we have not focussed, but our network comprises a set of actors who are reachable from that initially chosen set. Thus our "network" will most likely be a subset of all the actors that would meet the nominalist criteria. Consequently we have aspects of an "outside view" through the "nominalist" boundary specification, and something of an "inside view" through the expanding-selection method of data-collection. In addition, we have incorporated the notion of the network as a socially-constructed, rather than objectively-specified, entity.

METHODOLOGY

Social Network Analysis has been perceived generally as a quantitative methodology - although not necessarily "positivist" in approach (Hollstein 2008; Hollstein & Straus 2006; Heath et al. 2009). But there is also a long-standing empirical tradition of combining both qualitative and quantitative methods in network research (Scott 2000; Crossley et al. 2009), sufficiently marked in fact that it could be argued that the combination of methodologies is in fact the dominant tradition in most practical applications of Social Network Analysis. The development of a theoretical orientation towards mixing qualitative and quantitative approaches to Social Network Analysis has happened however only in very recent years (Crossley et al. 2009; Edwards & Crossley 2009; Edwards 2010).

Adopting the sampling procedure as outlined above, we applied SNA techniques to investigate the emergence and behaviour of SME (Small & Medium-scale Enterprise) dominated supply chain networks within a defined geography. Hence we focused on the impact of local embeddedness of such networks. In designing survey instruments for interviews, we follow Johnson & Turner's (2002) description for what they call "inter-method mixing" using an Interview Guide combined with a "Quantitative Interview". We use the Quantitative Interview primarily to gather quantitative network and relational information for SNA. We follow that with a traditional semi-structured interview in which we collect (network-oriented) qualitative data. We use two SNA software packages, Ucinet (Borgatti, *et al*., 2002) and Pajek (de Nooy and Vladimir, 2005).

FINDINGS

The study area, West Cork, Ireland, is characterised by a high density of food SMEs. Given this density we were interested in the role played, if any, by locally embedded networks, vertically, horizontally and 'diagonally' along the supply chain. We conducted interviews with 14 enterprises following the sampling procedure as outlined under methodology above. This provided a rich dataset organised around 'network relations' as the themes we were interested in were 'network centric'. Thus, for example, we were not interested in why a respondent was an entrepreneur but we were interested in why a respondent took actions to position his/her business better, to make a wider circle of connections or to seek new sources of knowledge. In particular, we were interested in network connections that were 'of importance to the business'. A number of interesting findings emerged that support the notion of eco-systems, these include: local network knowledge, role of customers in establishing reputation and extended supply chains.

Vertical Linkages
When investigating the importance of vertical supply chain linkages from the enterprise's perspective we find that 'importance' is often not associated with level of sales or even profitability. Rather it is the nature of the relations in terms of reputation, referrals and even association with the region. For example, one enterprise rated a local retail outlet among her top three customers, however further investigation revealed that sales through this outlet were very small compared to most other customers. This is particularly striking when compared with the other two 'important customers' identified, one of which is a leading speciality food retail outlet in London and the other of similar standing in Dublin.

The reason for the high rating was due to the impact that this local outlet had on the 'spatially extended short supply chain'. West Cork is popular with tourists who frequent the retail outlet and purchase the product. On return to their home county/country they continue to buy the product on-line. In the respondent's (R15) words: "*So that's been incredibly important - and that was very important from the beginning - the fact that were so many people with holiday homes who would come her on holiday and you'd just bump into them, you know, you'd bump into them in [the local shop or they'd buy your products and ring and say "Do you ship?*" The concept of the 'spatially extended short supply chain' was popularised by Marsden et al (2000; 2002) and Renting et al (2003).

They considered these chains short in that the product although transported over some distance is "embedded with value-laden information when it reaches the consumer ... [and] this enables the consumer to make connections with the place/space of production and, potentially, with the values of the people involved and production methods employed" (Renting et al 2003:400).

They confined their definition to customer who had never visited the region and illustrate with examples such as well-known regional specialities like Champagne wine or Parmigiano Reggiano cheese and also 'fair trade' food and beverage products. We find similar examples within our network, but these customers in many cases have visited the region and found the products in local retail and food service outlets (proximate supply chains). In this way we find an interesting interplay between 'spatially proximate short supply chains' and 'spatially extended supply chains'.

Thus the use of SNA mapping and associated qualitative data provides a useful insight into vertical linkages along the chain. This reasoning for identifying 'important customer linkages' (i.e. reasons other than sales, such as new product development/introduction, market feedback, retail reputation) is borne out by most enterprises that identify at least one of two local stores as among their top three customers. Figure 1 illustrates a segment of the SNA map with these two local retailers circled on the right-hand side.

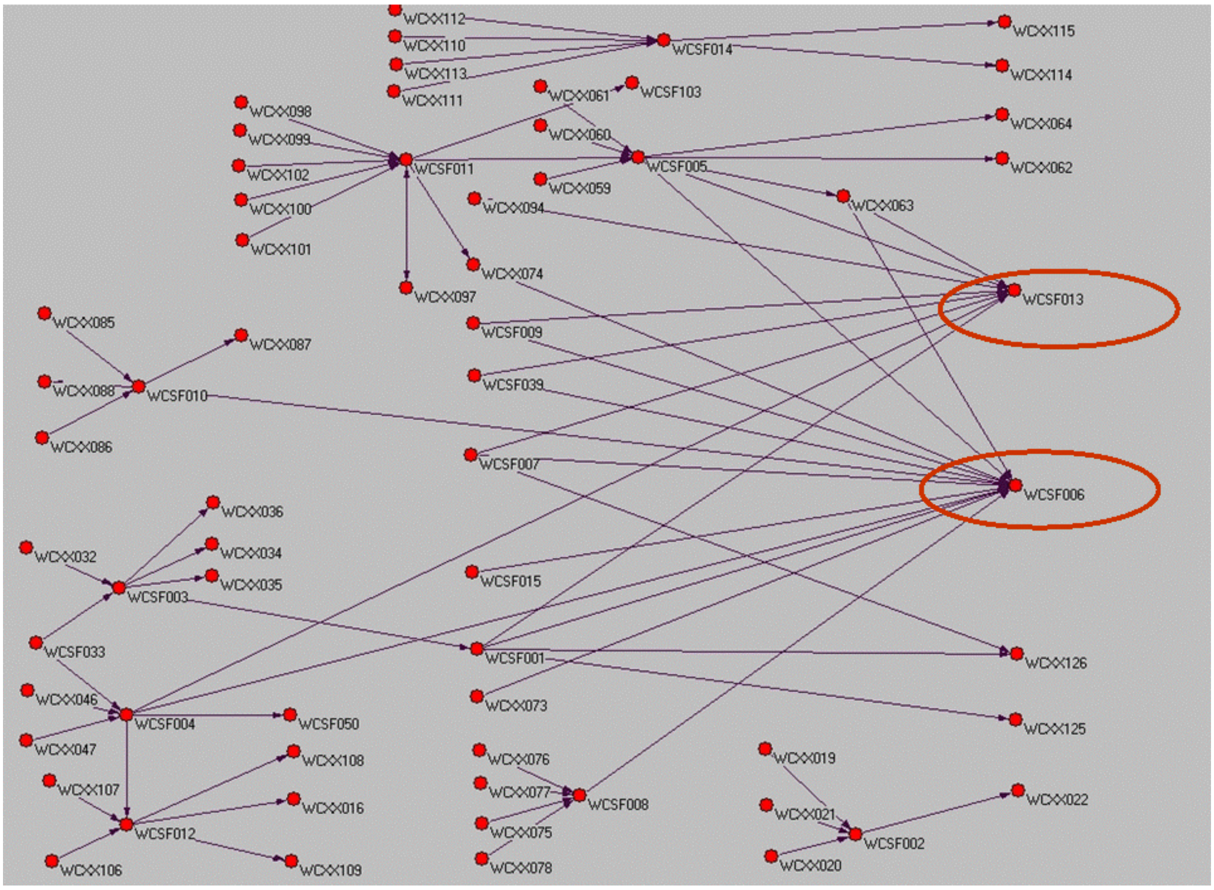

Figure 1: Importance vertical linkages

Horizontal and Diagonal Linkages

Given the findings above, it is no surprise that when measuring centrality these retailers were found to be at the centre of the map. Centrality mapping also identified other interesting linkages which support the notion of eco-systems embedded in local knowledge networks. For example, an enterprise (R10) recently established in the region had initially relied on contacts from outside the local network. However, in recent times he has established horizontal linkages with other enterprises in the area and these have become important sources of knowledge: "*Oh I would certainly … I visit the odd market when I'm around the place, and I take a stand down at a market with other food producers. And then through the networking events organized by the Cork Chamber [of Commerce] or the West Cork Enterprise Board - I'd meet them there, and we put together an informal group last year, with two or three other food producers, and we've actually made a few group purchases for ingredients - things like that, and traded packing insight and contacts*."

In addition to vertical and horizontal links, we investigated what is commonly termed 'diagonal linkages'. These are linkages with various service providers. The interplay between the density of food SMEs in the region and the number specialist service providers is of particular interest since we hypothesised that increasing specialisation resulted in the increasing importance of 'supply chain eco-systems'. However, other than linkages with public enterprise support agencies, we find that the role of vertical and horizontal linkages of greater importance to the success of these SMEs. This may be due to the small size of the firms and hence their level of expenditure on specialist services is somewhat limited. The level of horizontal interaction resembles that of the industrial districts and SME clusters that were first identified in the 1980s and popularised by scholars such as: Brusco (1996), Enright (1998), Kristensen (1992) and Pyke (1992). Indeed there are interesting parallels between this literature and recent interest in 'eco-systems'.

Interdependencies – pooled, sequential and reciprocal

It is interesting to find that the vertical interdependencies found among those with 'important linkages' are more pooled and reciprocal in nature than sequential. One might initially expect to find sequential type interdependencies important as these typify supply chain links, but in fact we find that reciprocal type interactions are more evident since it is these interactions that have broadened and deepened knowledge and skills, for example in areas such as: market information, customer contacts, and product development (Gulati and Singh, 1998; Lazzarini, *et al.* 2001.). We can return to our recently established business (R10) to illustrate. When this respondent's rationale for selecting his 'three top customers' was queried we discovered his largest customer was not included. When asked why this customer was not included in his 'top three' he responded: "*they are an important customer for sales revenue, but I just sell to them, it is just a transaction*". Whereas his interaction with his 'top customers' was much more reciprocal and this informed his thinking and improved business strategy and operations. Much of this information is tacit and leads to 'transformations' whereas sales and delivery processes are by nature more transactional and tend to be quickly codified.

We also found both pooled and reciprocal interdependencies along horizontal linkages. Figure 2 illustrates the emergence of a strong clique (bottom grouping) based primarily on horizontal linkages[6]. Some of the other linkages that members of this group have with other actors are shown in the top right hand corner (these are primarily first tier suppliers) and two 'enterprise outliers' are in the top left hand corner.

Thus we find that SNA coupled with qualitative data provides a good insight into the interplay of different forms of proximity: spatial, organizational and relational; and into the relative importance of codified and tacit knowledge in creating competitive advantage. In addition, we observed a clear distinction between means used to establish relationships and those used to maintain them.

[6] It is interesting that the 'two local retailer' indentified earlier are also member of this clique since they behave as co-producers.

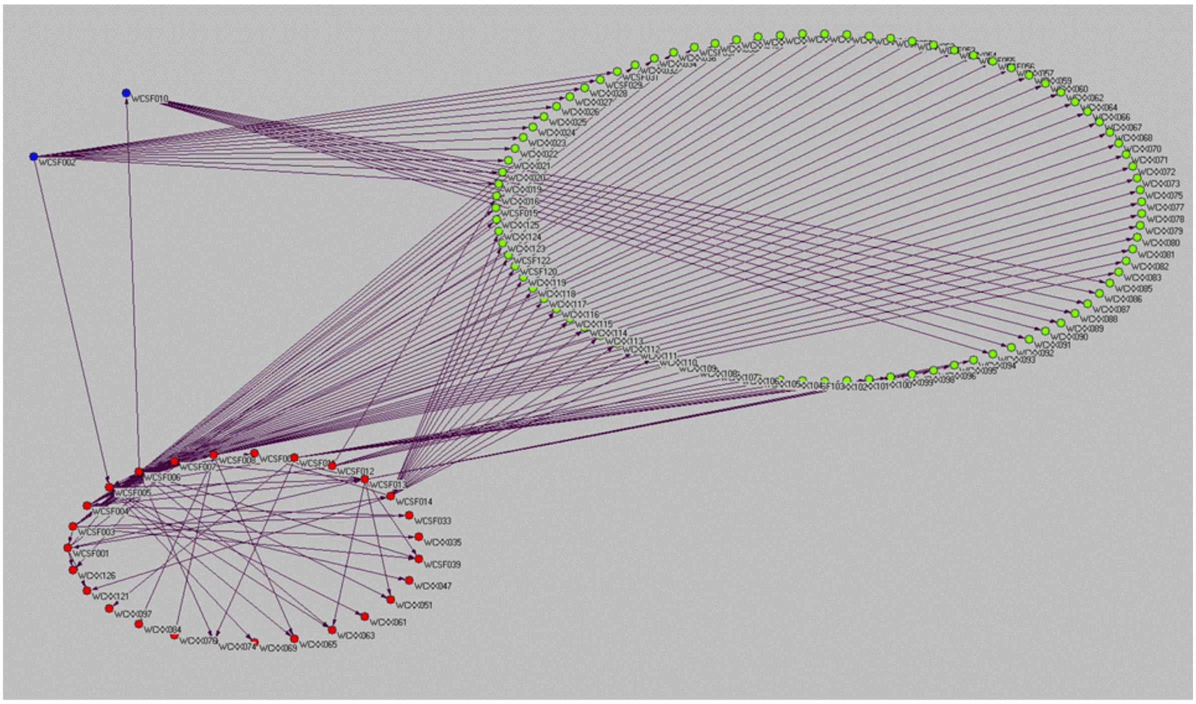

Figure 2: Horizontal linkages – An Enterprise Clique

In summary, our findings support the argument that the networks are neither exogenously determined nor static. Rather they are "snapshots" in time that are created (and modified) by the agency of the actors within the network – oftentimes guided by or constrained by the network position in which those actors find themselves at that particular point in time. Thus our networks are socially constructed.

CONCLUSIONS

Our intent was to collect complementary data and to use the results from each method in turn to guide further iterations with that and/or the alternate method. Thus a finding from SNA that a group of actors form a subgroup or "clique" would cause us to examine the qualitative data (or collect more) to determine possible explanations for this. One important reason for doing this is that SNA can be overly mechanistic, and results may be misleading or simply hard to interpret without sound theoretical and empirical understanding of the network structure being studied and also of details of the survey methods adopted. This approach provided a useful insight into network establishment and evolution. In particular, this approach allows us to incorporate 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.

Our application of SNA techniques is limited to a study of SME dominated supply networks. Furthermore, our focus on local embeddness ignores the increasing importance of global interactions along supply networks. However, within the limited scope of our study we find the use of mixed methods, including SNA techniques, offers a useful analytical approach to the study of what has often been considered a rather intangible phenomenon. In particular, we find SNA techniques, such as subgroup/ cliques and centrality measures, useful in studying emerging supply network 'eco-systems'. While this initial work offers promise further application of these techniques to a wider range of supply networks, including those involving larger scale organisations and wider spatial boundaries, is required.

REFERENCES

Borgatti, S. P., M. G. Everett, and L. C. Freeman. (2002) *ucinet for Windows: Software for Social Network Analysis*, Harvard: Analytic Technologies.

Braudel, F. (1982) *Civilization and Capitalism, 15th-18th Century. Volume 2: The Wheels of Commerce*, London: William Colins Sons & Co. Ltd.

Brusco, S. (1996) "Trust, Social Capital and Local Development: Some Lessons from the Experience of the Italian Districts", in *Networks of Enterprise and Local Development: Competing and Co-operating in Local Productive Systems*, OECD: Paris: 115-120.

Carrington, Peter, and John Scott, eds. 2010. *The Sage Handbook of Social Network Analysis*. Thousand Oaks, CA: Sage Publications, Inc.

Carrington, Peter, John Scott, and Stanley Wasserman. 2005. *Models and Methods in Social Network Analysis*. Cambridge, UK: Cambridge University Press.

Crossley, N., Prell, C. & Scott, J. (2009) Social Network Analysis: Introduction to Special Edition. *Methodological Innovations Online*, 4, 1–7.

Doreian, P. & Woodard, K.L., 1992. Fixed List versus Snowball Selection of Social Networks. *Social Science Research*, 21, 216-233.

Dervitsiotis K., N. (2008) Guiding human organisations to climb the spiral stages of performance improvements, *Total Quality Management & Business Excellence*, Vol 19, issue 7 & 8, pp. 709-718.

van Duijn, Marijtje A. J., and Jeroen K. Vermunt. 2006. "What Is Special About Social Network Analysis?." *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences* 2:2-6.

Edwards, G. (2010) *Mixed-Method Approaches to Social Network Analysis*, National Centre for Research Methods.

Edwards, G. & Crossley, N. (2009) "Measures and Meanings: Exploring the Ego-Net of Helen Kirkpatrick Watts, Militant Suffragette" *Methodological Innovations Online*,4:37-61.

Enright, M. (1998) "Regional Clusters and Firm Strategy," " in Chandler, A.D., Hagström, P. and Sölvell, Ö (eds.), *The Dynamic Firm*, Oxford University Press, pp 315-342.

Gulati, R. and Singh, H. (1998) "The architecture of cooperation: managing coordination costs and appropriate concerns in strategic alliances", Administrative Quarterly 43: 781-814.

Heath, S., Fuller, A. & Johnston, B. (2009) Chasing Shadows: Defining Network Boundaries in Qualitative Social Network Analysis. *Qualitative Research*, 9(5), 645-661.

Hollstein, B (2008) Qualitative Methods in Network Analysis. In Seminar: "The Quantitative-Qualitative Interface in Social Network Analysis". Colchester, UK.

Hollstein, B. & Straus, F. (2006) *Qualitative Netzwerkanalyse*, Available at: http://dx.doi.org/10.1007/978-3-531-90074-2 [Accessed December 25, 2009].

Johnson, B. and Lisa A. T., (2002) "Data Collection Strategies in Mixed Methods Research," Pp. 297-320 in *Handbook of mixed methods in social & behavioral research*. Thousand Oaks, CA: Sage Publications.

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. http://www.qualitative-research.net/index.php/fqs/article/view/966.

Knoke, D. and Kuklinski, J. H. (1982) *Network Analysis*. Thousand Oaks, CA: Sage Publications, Inc.

Kristensen, P. (1992) "Industrial districts in West Jutland, Denmark", in Pyke, F. and Sengenberger, W. (eds.) *Industrial districts and local economic regeneration*, International Institute for Labour Studies: Geneva: 124-173

Laumann, E. O., Marsden, P. V. and Prensky P. (1983) "The Boundary Specification Problem in Network Analysis" pp. 18-34 in *Applied Network Analysis: A methodological Introduction*. Thousand Oaks, CA: SAGE.

Lazzarini, S., Chaddad, F. & Cook, M. (2001) Integrating Supply Chain and Network Analyses: The Study of Netchains. *Journal on Chain and Network Science*, 1(1), 7-22.

Marin, Alexandra, and Barry Wellman. 2010. "Social Network Analysis: An Introduction." in *The Sage Handbook of Social Network Analysis*, edited by Peter Carrington and John Scott. Thousand Oaks, CA: Sage Publications, Inc.

Marsden T, Banks J, Bristow G, (2000), "Food supply chain approaches: exploring their role in rural development" *Sociologia Ruralis* 40: 424- 438.

Marsden T, Banks J, Bristow G, 2002, ``The social management of rural nature: understanding agrarian-based rural development'' Environment and Planning A 34:809-825.

de Nooy, Wouter, A. M., and Vladimir B. (2005) *Exploratory Social Network Analysis with Pajek*, illustrated edition. Cambridge, UK: Cambridge University Press

Pyke, F. (1992) *Industrial Development though Small-Firm Co-operation: Theory and Practice*, International Labour Organisation: Geneva.

Renting H., Marsden, T. Banks J. (2003) "Understanding alternative food networks: exploring the role of short food supply chains in rural development"' *Environment and Planning* A 35 393 -411

Simichi-Levi, D., Kaminsky, P. and Simichi-Levi, E. (2008), Designing and managing the supply chain: Concepts, strategies and case studies, (3rd Ed.) McGraw-Hill, Boston.

Scott, John. 2000. *Social Network Analysis: A Handbook*. 2nd ed. London: SAGE Publications Ltd.

Simmel, Georg. 1908. *On Individuality and Social Forms: Selected Writings*. Chicago, IL: University of Chicago Press.

Wasserman, Stanley, and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

COMPETENCY GAP ASSESSMENT FOR OPERATIONS MANAGERS: A CASE STUDY OF A LARGE AUSTRALIAN LOGISTICS FIRM

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ABSTRACT
Purpose - The objective of this study is to assess the competency gap of operations managers of a large logistics firm in Australia and to identify areas for improvement.

Design/methodology/approach - A survey instrument with four functional and eight fixed competencies was used to collect data. A factor analysis of the collected data produced four functional and six fixed competencies. Paired t-test was performed to assess the significance of difference between importance and current competency. The items/tasks of the derived competencies were then subjected to importance-competence matrix (ICM) analysis.

Findings - The top three competencies assessed by the operations managers are integrity, delighting customers, and managing results. The difference between importance and current competency level for all competency items were found to be significant at $p < 0.01$ and $p < 0.05$. ICM analysis shows that within the functional competency cluster four task-related competencies required to be further developed, whereas, within the fixed competency cluster seven task-related competencies needs to be developed.

Practical implications - Results of the can be used to develop training materials and programs for operations managers of the case study organisation and for other similar logistics firms in Australia.

Original value of paper - This study provides a simple but an innovative approach for assessing competency gap and identifying training needs.

Type of paper - Research paper

Keywords – Australia, Managerial competency, Operations manager, Logistics firm.

INTRODUCTION

For long-term success of any firm the management of human resource is critical (Johnson et al. 1986). Given the current volatile business environment, development of right competencies for the workforce has become extremely challenging. One way to sustain and improve skills and competencies is through competency-based training. Although its origin can be traced back in 1920s, the concept of competency-based training and education, sometimes known as performance-based or outcome-based training, has evolved from around 1960s onward (Burke, 1989). The training approach has also been integrated into the national education system such as National Vocational Qualifications system in England, Australia and New Zealand (Kerka, 1998).

Defining competency

The term competency has been defined by many authors and in many different ways. For example, Drejer (2001) defined competency as "a system of human beings, using technology in an organized way and under the influence of a culture to create an output that yields competitive advantage for the firm". Tobias and Dietrich (2003) defined it as a set of personal characteristics which are relatively stable across different situations. Taking a strategic perspective Hitt, et al. (2005) defined competency as a combination of resources and capabilities within an organisation. In this research, we consider competency as a measurable cluster of related knowledge, skills, and attitudes that correlates with effective performance of a job, organization or culture, and that can be improved through training (Richey at al., 2001; Hay Group, 2001). This definition of competency includes only what seems to be trainable.

Depending on the context and perspective, the term competency may attribute multiple meanings. For example, in the US, competencies are seen as inputs of human behaviour – skills and attributes that affect an individual's ability to perform. In the UK, however, competencies are seen mainly as outputs - degree to which an individual's performance meet or exceeds predetermined task standards (Heffernan and Flood, 2000; Brophy and Kiely, 2002). Also, competencies can be viewed as generic and technical (Boyatzis, 1982). Generic managerial competencies include self-regulation and self-control capabilities such as attitudes or motivation which are appropriate for more generic situations (Agut et al., 2003). Technical competencies include skills that enable managers to perform effectively in specific areas of management such as logistics. Competencies in organizations can also be broadly classified as employee-level and organization-level (Cardy and Selvarajan, 2006). Since organization-level competencies are determined by employee-level competencies, development of the latter is critical for organisations' competitive advantage.

Competency gap

One approach to assess firms' competency needs is through the competency-gap analysis (Barber and Tietje, 2004; Scholes and Endacott, 2003). At the employee-level, competency-gap can be defined as the difference between the level of competency required for effective job performance and the level of competency possessed by an individual. Once the gaps are identified, appropriate strategies can be put in place to narrow these gaps. Thus, a competency development framework based on the competency-gap analysis, according to Wickramasinghe and De Zoyza (2009) can help 'align the HR system vertically with organisation's strategic objectives and horizontally with other HR functions, where it provides a tool for selection, performance management, training and development, and career management' (p. 2548). The purpose of this research is to identify the competency-gaps of the operations managers of a global logistics firm operating in Australia, and to suggest areas for further improvement.

Case study: Company X

The company is a global logistics firm earning over AUD14 billion worldwide. It serves in more than 190 countries and employs around 150,000 people globally. The company picks, transports, sorts, handles, stores and delivers documents, parcels, and freight by combining physical infrastructures such as depots and trucks, electronic infrastructures such as billing and track & trace systems, and commercial infrastructures to attract, serve and retain customers. It has the operational capacity and flexibility to ensure the timely pick-up and delivery of freight, particularly through peak periods and is experienced at driving efficiencies across the customer supply chains. It is company's motto to deliver the 'businesses' of its customers at the right time and at the right place. The company offers services to clients to ensure that parcels, documents and freight items are delivered safely and on time throughout the world. In addition to servicing a wide range of clients, in Australia, the company has been named as a preferred transport provider for the largest hardware chain in Australasia, which partners with over 900 Australian and international suppliers. The company is strongly committed to responsible corporate citizenship and implements various international standards.

RESEARCH METHODOLOGY

Respondents

Using a survey questionnaire 38 operations managers currently working with company X were surveyed. The questionnaire was developed based on four functional competencies and eight fixed competencies which are currently being applied to evaluate the performance of the operations managers. Four functional and eight fixed competencies were in turn defined by 17 and 34 items/task-level competencies respectively (Figure 1).

Respondents were briefed about the purpose of the study prior to questionnaire distribution and their responses were anonymous. They were asked to indicate the level of importance as well as the level of competency they currently possess against each of the 51 items/tasks.

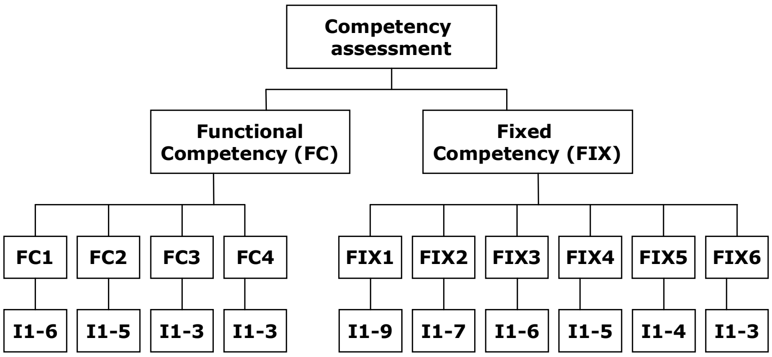

Figure 1: Competencies and items

The perceived competency and importance levels were measured as follows:

Item/task importance-level: 'Think of the items/tasks listed; rate the competency importance in performing the listed tasks'. A 5-point likert scale was used to establish the level of importance with 1 being low, 5 being very high, and 0, when an item is not relevant.

Current competency-level: 'Think of the items/tasks listed; rate the competency level you currently posses in performing the listed tasks'. A 5-point likert scale was used to establish the current competency-level with 1 being low, 5 being very high, and 0, when an item is not relevant.

The difference between the levels of importance they assigned and the levels of competency they currently possessed provided the competency gap at the task-level.

Methods of analysis

First, responses were subjected to exploratory factor analysis, separately for the functional and fixed competencies. This resulted in four functional and six fixed higher-level competencies. Both factor loadings and reliability coefficients (cronbach's alpha) ranged within the acceptable level (Table 1 and Table 3). However, two items from the fixed competency cluster did not load appropriately and were dropped from the list of the items/tasks for further consideration. Descriptive statistics were used to analysis scores of importance and current competency-level. Paired t-test was performed to assess the significance of difference between current importance and current competency.

Following the guideline suggested by Agut and Grau (2002) and Agut et al. (2003), three types of competency gaps were identified. These are 'positive gap' (PG) (importance level is higher than the current competency level by a value of > 0.5); 'negative gap' (NG) (importance level is lower than the current competency level by a value of < - 0.5), and 'adjustment margin' (AM) (current competency level is lower than the importance level but close to that required: -0.5 ≤ value ≤ 0.5.

Fifty-one items of ten competencies (four functional and six fixed) were then subjected to importance-competence matrix (ICM) analysis. ICM is one of the more widely used gap-based methods proposed by Martilla and James (1977). The utility of the ICM analysis lies in its capacity to represent both importance and competence perspectives with regards to the relative improvement priorities required in a competitive environment. This method has been applied widely in various contexts (Skok et al., 2001; Lai and Cheng, 2003).

RESULTS AND DISCUSSION

Results of the functional competencies

Table 1 summarises the results of the exploratory factor analysis for functional competencies. The analysis derived four functional competencies with factor loadings ranging between 0.53 and 0.88, and reliability coefficients ranging between 0.75 and 0.86. Both factor loading and reliability coefficient are found to be within the acceptable range (Hair et al. 1998).

The results relating to competency-gap are given in Table 2. The competency gaps of all 17 items belonging to four functional competencies are found to be 'positive' (difference is > 0.5) and significant at $p < 0.01$. The highest and lowest mean differences are for FC15 (value = 1.26) and FC23 (value = 0.51) respectively.

Items	Functional competency clusters				Cronbach's
	1	2	3	4	alpha
FC11	0.88				
FC12	0.81				
FC13	0.71				
FC14	0.65				0.83
FC15	0.61				
FC16	0.53				
FC21		0.78			
FC22		0.68			
FC23		0.68			0.86
FC24		0.62			
FC25		0.61			
FC31			0.84		
FC32			0.72		0.79
FC33			0.61		
FC41				0.77	
FC42				0.74	0.75
FC43				0.73	
Eigenvalues	7.755	2.244	1.724	1.5	
Variance Explained %	40.82	11.81	9.07	7.89	

Table 1: Factor analysis of functional competencies

Figure 2 shows the results of ICM analysis. Out of 17 tasks, 7 fell in the 'keep up the good work' quadrant: FC21, FC22, FC23, FC24, FC31, FC32 and FC41. Four tasks fell in the 'concentrate here' quadrant. These tasks are;

FC13: Implement disciplinary actions if required (Higher level competency: Coaching others)

FC16: Providing effective employee counselling when needed (Higher level competency: Coaching others)

FC25: Relevant information is passed on to employees/subcontractors using appropriate language PUD, operations, Customer Service and Sales (Higher level competency: Verbal communication)

FC42: Increase efficiency and effectiveness of work methodologies within the boundaries of the operation processes and quality standard (Higher level competency: Accuracy).

The findings indicate that further training is necessary in areas such as Coaching others and accuracy. For effective performance, it is important that the senior management concentrates on these tasks and allocate appropriate resources for further development of competencies in these areas.

Item	Level of importance		Current level of competency		Difference	Type of gap	t-value	P-value
	Mean	Sdev.	Mean	Sdev.				
FC11	3.76	.95	2.92	1.28	.84	PG	3.980	.000
FC12	3.92	1.01	3.35	1.11	.57	PG	3.402	.002
FC13	4.06	1.12	3.16	1.09	.89	PG	3.679	.001
FC14	3.78	1.20	3.00	1.41	.78	PG	4.205	.000
FC15	3.14	1.77	1.88	1.53	1.26	PG	5.505	.000
FC16	4.26	.72	3.21	.96	1.05	PG	5.376	.000
Mean	**3.82**		**2.92**		**.90**	PG		
FC21	4.05	.91	3.61	.93	.44	PG	3.101	.004
FC22	4.08	.83	3.51	.77	.57	PG	3.601	.001
FC23	4.37	.73	3.86	.85	.51	PG	3.100	.004
FC24	4.19	.66	3.57	.83	.62	PG	3.851	.000
FC25	4.08	1.06	3.27	1.24	.81	PG	4.821	.000
Mean	**4.16**		**3.56**		**.59**	PG		
FC31	4.32	.99	3.76	.80	.56	PG	4.104	.000
FC32	4.18	.76	3.34	1.11	.83	PG	4.070	.000
FC33	4.03	.74	3.42	.84	.61	PG	4.568	.000
Mean	**4.17**		**3.51**		**.66**	PG		
FC41	4.15	.96	3.47	1.11	.68	PG	4.176	.000
FC42	4.06	.90	3.21	.98	.85	PG	3.990	.000
FC43	3.91	1.03	3.15	1.08	.76	PG	3.947	.000
Mean	**4.04**		**3.27**		**.77**	PG		

Table 2: Competency-gaps and their significance (all differences are significant at $p < 0.01$)

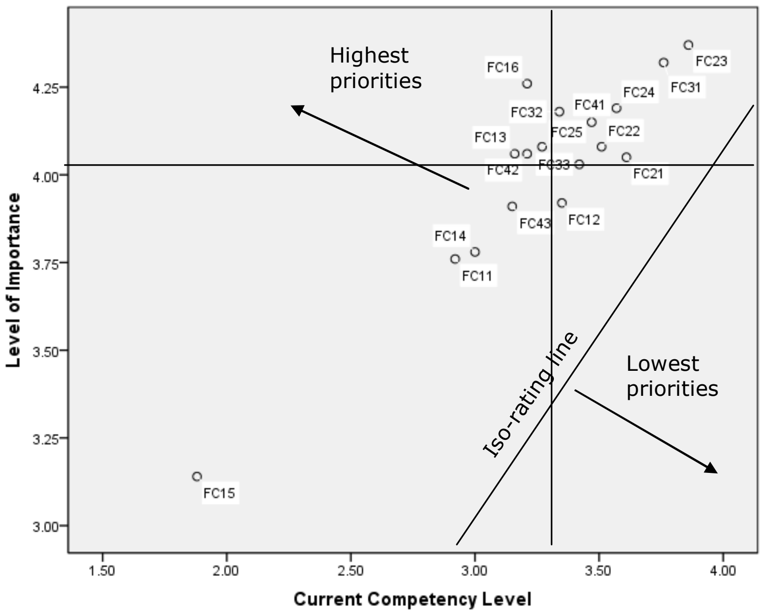

Figure 2: Importance-competency analysis for functional competencies

Results of the fixed competencies
Table 3 summarises the results of the exploratory factor analysis for fixed competencies. The analysis resulted in six fixed competencies with factor loadings ranging between 0.51 and 0.90, and reliability coefficient ranging between 0.86 and 0.95. Both factor loading and reliability coefficient are found to be within the acceptable range (Hair et al. 1998).

The results relating to competency-gap are given in Table 4. The competency gaps of 27 tasks are found to be 'positive' (difference is > 0.5) and the rest fell in the 'adjustment margin' category (-0.5 ≤ value of ≤ 0.5). All competency gaps are significant at $p < 0.01$, accept for the task FIX42, gap of which is significant at $p < 0.05$. The highest and lowest mean differences are for FIX25 (value = 1.06) and FIX44 and FIX61 (value = 0.28) respectively.

Items	Fixed competency clusters						Cronbach's alpha
	1	2	3	4	5	6	
FIX11	.90						
FIX12	.85						
FIX13	.85						
FIX14	.80						
FIX15	.73						0.95
FIX16	.69						
FIX17	.67						
FIX18	.56						
FIX19	.53						
FIX21		.87					
FIX22		.72					
FIX23		.70					
FIX24		.66					0.92
FIX25		.59					
FIX26		.59					
FIX27		.51					
FIX31			.78				
FIX32			.73				
FIX33			.66				
FIX34			.64				0.91
FIX35			.61				
FIX36			.51				
FIX41				.86			
FIX42				.73			
FIX43				.70			0.88
FIX44				.67			
FIX45				.52			
FIX51					.71		
FIX52					.71		
FIX53					.71		0.86
FIX54					.58		
FIX61						.81	
FIX62						.80	0.82
FIX63						.70	
Eigenvalues	17.294	2.775	2.676	2.433	2.116	1.743	
Variance Explained %	17.558	13.832	10.975	10.113	9.266	8.022	

Table 3: Factor analysis of fixed competencies

Items	Level of Importance		Current Competency Level		Difference	Type of gap	t-value	P-value
	Mean	Sdev	Mean	Sdev				
FIX11	4.17	1.134	3.74	.950	0.42	AM	3.93	.000
FIX12	4.25	.937	3.39	.903	0.86	PG	5.38	.000
FIX13	4.09	1.197	3.40	1.241	0.69	PG	4.55	.000
FIX14	4.00	1.350	3.48	1.149	0.52	PG	4.65	.000
FIX15	4.46	.650	3.70	.777	0.76	PG	5.33	.000
FIX16	4.47	.910	4.09	.702	0.39	AM	4.62	.000
FIX17	4.44	.695	3.69	1.037	0.75	PG	4.28	.000
FIX18	4.25	.996	3.60	.775	0.65	PG	4.42	.000
FIX19	4.08	.770	3.57	.855	0.51	PG	3.180	.001
FIX21	3.91	1.011	3.23	1.031	0.69	PG	4.35	.000
FIX22	4.40	.812	3.86	.974	0.54	PG	3.93	.000
FIX23	4.35	.824	3.76	.983	0.59	PG	3.90	.000
FIX24	4.30	.702	3.49	.768	0.81	PG	4.70	.000
FIX25	3.97	1.028	2.92	1.296	1.06	PG	4.42	.000
FIX26	4.16	.718	3.42	.758	0.74	PG	4.52	.000
FIX27	4.14	.787	3.49	.932	0.65	PG	4.16	.000
FIX31	4.31	.676	3.69	.832	0.63	PG	4.61	.000
FIX32	4.33	.632	3.56	.773	0.78	PG	5.86	.000
FIX33	4.40	.651	3.54	.886	0.86	PG	5.37	.000
FIX34	4.24	.683	3.73	.769	0.51	PG	3.25	.003
FIX35	4.38	.681	3.70	.812	0.68	PG	4.65	.000
FIX36	4.35	.676	3.65	.824	0.70	PG	4.01	.002
FIX41	4.53	.609	4.00	.793	0.53	PG	4.30	.000
FIX42	4.61	.599	4.28	.659	0.33	AM	2.52	.016
FIX43	4.49	.607	3.92	.682	0.57	PG	4.51	.000
FIX44	4.25	.874	3.97	.687	0.28	AM	4.31	.000
FIX45	4.25	.874	3.53	1.028	0.72	PG	4.32	.000
FIX51	4.34	.627	3.88	.784	0.46	AM	3.20	.003
FIX52	4.53	.557	4.01	.809	0.51	PG	3.83	.000
FIX53	4.30	.661	3.80	.795	0.50	AM	3.81	.001
FIX54	4.32	.747	3.76	.925	0.57	PG	3.50	.001
FIX61	3.57	1.596	3.29	1.160	0.28	AM	4.91	.000
FIX62	4.08	1.171	3.29	1.160	0.79	PG	5.38	.000
FIX63	3.81	.822	3.19	.710	0.61	PG	3.80	.001

Table 4: Competency-gaps and their significance (all differences are significant at $p < 0.01$)

Figure 3 shows the results of ICM analysis. Out of 34 tasks, 16 fell in the 'keep up the good work' quadrant and 7 tasks fell in the 'concentrate here' quadrant. Management must give highest priority to improve the competencies for the following tasks:

- FIX12: Explore the expectations and needs of the customer in a structured way (Higher level competency: Delight customer)
- FIX18: Offers solutions that meet the needs of the customer (Higher level competency: Delight customer)
- FIX24: Gives instructions to complete day-to-day tasks and explains why (Higher level competency: People management)
- FIX32: Is decisive and action oriented (Higher level competency: Managing results)
- FIX33: Recognizes opportunities to improve customer delight and takes action (Higher level competency: Delight customer)
- FIX36: Conveys the message clearly, correctly and comprehensively (Higher level competency: Communication)
- FIX45: Communicates relevant TNT Policies effectively to appropriate stakeholders (Higher level competency: Communication).

The results indicate that training is required in areas such as delighting customers, people management, and communication.

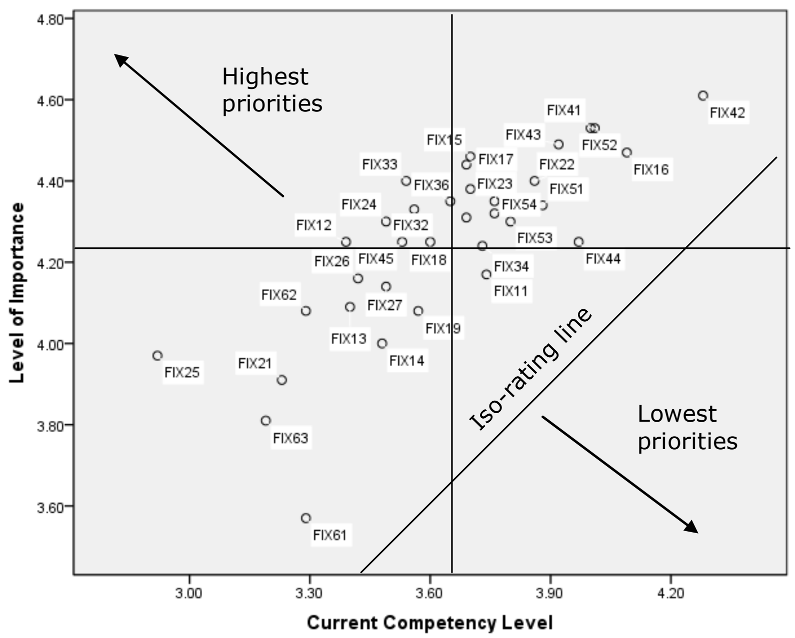

Figure 3: Importance-competency analysis for fixed competencies

CONCLUSION

Using a self-assessment survey approach this research identified the gap between the level importance assigned to a task and level of competency an operations manager currently possess. All gaps were found to be positive and significant, i.e., in order to narrow the competency-gap further training is required for all tasks. Using ICM analysis the study identified a list task-related competencies that requires immediate attention, which belongs to higher level competencies such as ‘delight customer’, ‘people management’, ‘communication’ including verbal communication, and ‘coaching others’.

REFERENCESAgut, S and Grau, R (2002), “Managerial competency needs and training requests: the case of the Spanish Tourist industry”, *Human Resource Development Quarterly*, 13, 1, pp.31-51.

Agut, S., Grau, R. and Peiro, J. M (2003), “Individual and contextual influences on managerial competency needs”, *Journal of Management Development*, 22, 10, pp. 906-918.

Barber, C S and Tietje, B C (2004), “Competency requirements for managerial development in manufacturing, assembly, and or material processing functions”, *Journal of Management Development*, 23, 6, pp. 596-607.

Boyatziz, R E. (1982), *The Competent Manger – A Model for Effective Performance*, NY: Wiley.

Brophy, M and Kiely, T (2002), “Competencies: a new sector”, *Journal of European Industrial Training*, 26, 2, 3, & 4, pp. 165-176.

Burke, J W. (1989), *Competency Based Education and Training*, Routledge, London.

Cardy, R L and Selvarajan, T T (2006), “Competencies: Alternative frameworks for competitive advantage’, *Business Horizons*, 49, pp. 235-245.

Drejer, A (2001) “How can we define and understand competencies and their development?, *Technovation,* 21, pp. 135-146.

Hair, J F, Anderson, R E, Tatham, R L and Black, W C (1998), *Multivariate Data Analysis*, Prentice-Hall International, Inc. NJ.

Hay Group (2001), “The manager competency model”, www.hayresourcesdirect. haygroup. Com

Heffernan, F and Flood, P (2000), “An exploration of the relationships between the adoption of managerial competencies, organisational characteristics, human resource sophistication and performance in Irish organisations”, *Journal of European Industrial Training*, 24, 2, 3 & 4, 128-136.

Hitt, M A, Ireland, R D and Hoskisson, R E (2005), *Strategic Management: Competitiveness and globalization*, 6th edition, Versailles, KY: South-Western.

Johnson, R A, Neelankavil, J P and Jadhav, A (1986), “Developing the executive resource”, Business Horizonz, Nov. – Dec., pp. 29-33.

Kerka, S (1998), “Competency-based education and training: myths and realities”, ERIC Clearinghouse on Adult, Career and Vocational Education, Columbus, OH, at: www.eric.ed.gov/

Lai, K-H and Cheng, T. C. E. (2003), Supply chain performance in transport logistics: an assessment by service providers, *International Journal of Logistics: Research and Applications*, Vol. 6 No. 3, pp. 151-164.

Martilla, J. A. and James, J. C. (1977), Importance-performance analysis, *Journal of Marketing*, Vol. 41 No. 1, pp. 77-79.

Richey, R, Fields D and Foxon M (2001), *International Board of Standards for Training, Performance and Instruction: Instructional Design Competencies: The Standards*, third edition, ERIC Clearinghouseon Information Technology.

Scholes, J and Endacott, R (2003), “The practice competency gap: challenges that impede the introduction of national core competencies”, *Nursing in Critical Care*, 8, 2, pp. 68-77.

Skok, W., Kophamel, A. and Richardson, I. (2001), "Diagnosing information systems success: importance-performance maps in the health club industry", *Information & Management*, Vol. 38, pp. 409-419.

Tobias, L and Dietrich, A (2003), "Identifying employee competencies in dynamic work domains: methodological consideration and a case study, *Journal of Universal Computer Science*, 9, 12, 1500-1518.

Wickramasinghe and De Zoyza (2009),"An assessment of managerial competency needs: empirical evidence from a Sri Lankan telecommunication service provider", *The International Journal of Human Resource Management*, 20, 12, 2547-2567.

THE POTENTIAL OF SERIOUS GAMES FOR SUPPORTING THE IMPLEMENTATION OF THE INTELLIGENT CARGO CONCEPT IN SUPPLY NETWORKS

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ABSTRACT
The introduction of new ICT as well as changes in organizational structures generate new requirements in the skills and competencies of involved staff, which needs to be mediated (Hausladen, 2008, EURIDICE 2009b). Additionally, employees need to be aware of possible impacts; to understand how these technologies affects the processes as well as being able to handle any new devices. The past experience of the authors' research organisation (Windhoff, 2001, Schwesig, 2005, Baalsrud Hauge, 2007), shows that serious games have the potential to support exactly these measures. In this paper, the applicability of serious games is discussed to support the introduction and implementation of the intelligent cargo concept within supply networks under consideration of different stakeholders.

This article discuss the potentials and limitations of using serious games for mediating skills needed for applying advanced ICT concepts in supply networks. It also discusses under which circumstance such games can be used for increasing the awareness and the understanding of the impact these technologies man have on the business processes in supply networks.

INTRODUCTION
Today, technological progress leads to changes in market scenarios, which affect the purchase, production and sales structures of consigning companies. Suppliers, manufacturing sites and customers are located internationally. At the same time, simplification of processes, enhancement of flexibility and the continuous requirement for cost reduction results in more and more tasks being outsourced as well as the trend toward complex products with short product life cycle time cause a close collaboration among global distributed partners and finally to the evolvement of global supply chain networks.

Multi modal supply networks comprise stakeholders like shipping agents, consignees, dispatchers, ocean carriers or port authorities in additional to the supplier and customer. The goal of these networks is the optimisation of logistical and production processes (Pfohl, 2002, Jüttner, 2005). The efficiency and operative excellence of the logistic processes is of predominant importance. The objective of the management of supply chain networks is therefore to manage both material and information flows throughout the entire network; mostly this is driven by the cargo owner. The corresponding information flows between these stakeholders are of complex nature, since each partner has different requirements on the structure and format as well as on the information content, depending on whether we consider the upstream information accompanying the material flow (freight papers, status information) or downstream information flowing in the opposite direction (like order fulfilment and confirmation). For planning and coordination reasons it would be preferable to have real time access to the status information, but this is hardly possible at the moment. Consequently, most of the planning and coordination processes are based on limited information access and no real time data access although modern information and communication technologies (ICT) could provide real time status information.

The Figure 4 below illustrates a simple supply chain, leaving out the logistic service providers, but still it illustrates one of the main problems: the asynchronous information and material flows and the number of interfaces within these flows.

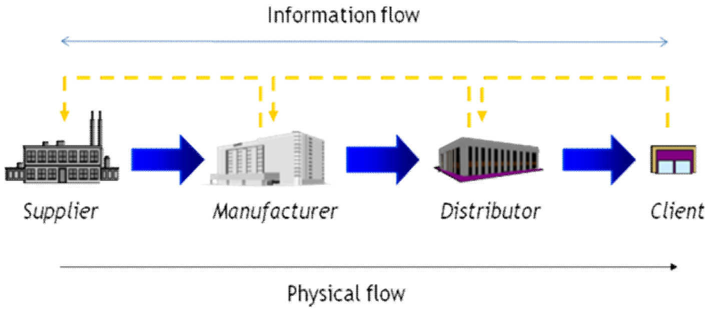

Figure 4: Simplified supply chain (TSLU, VIU, 2009)

Even though much effort is allocated for meeting the goal of high percentage of delivery on time by using tracking and tracing technologies, Wolters Kluwer (Wolters Kluwer 2005) states that a large number handles the information manually. Consequently, it is still a challenge to deliver the right goods in the right amount and quality and order at the right place on time (Sörensen, 2005, Jüttner, 2005, Pfohl, 2002). The reason for this is manifold: The networks comprise several different entities like the suppliers, the producers, warehouses and distribution centres as well as all the logistic service providers carrying and handling the goods on its way from one location to another.

The availability of today's modern ICT enables the acquisition, processing and distribution of almost any information about a shipping order independent from its current location. Additionally to the challenges companies discovers at a micro economic level, the lack of seamless and synchronous information flow does have a large impact on the environment. Hence, the European Commission has released a research agenda on "Mobility Services for goods" (EU, 2006) aiming at:

- *Creating a seamless efficient (goods) mobility service system using ICT as an enabler.*
- *Exploiting RFID and ICT platforms as critical component and architecture.*
- *Urban logistics supported by network management.*
- *High level of liable security and of adequate tracking and tracing*

A concept to enrich the freight to be shipped by intelligent ICT and thus contributing to the research agenda on the mobility of goods is the "Intelligent Cargo Concept" (EURIDICE, 2009). The aim is to improve the planning and coordination processes of different stakeholders in a supply network.

INTELLIGENT CARGO CONCEPT AND THE IMPACT ON SUPPLY CHAIN OPERATION

In the introduction it was stated that by attaching the information to the cargo or a complete integration of the different proprietary systems at each individual entity would reduce the problems caused by the asynchronism effectively.

It is evident that the main technological components for the realisation are available today. Such technologies comprises Radio-Frequency Identification technologies (RFID), service oriented architectures (SOA), interoperability platforms for data interchange and collaboration between business partners, mobile technologies and global positioning systems. However, it is also evident that these technologies are only partly implemented and in operation throughout the supply chain (Riedel, 2007) even though it can be shown that RFID technologies for instance can increase the efficiency and the traceability to a large extent (Water and Rahman, 2008), but there is the lack of large scale implementations benefitting the majority of logistic operators and users.

Figure 5 shows again the information and material flow as well as visualize the function an information and communication system needs to handle.

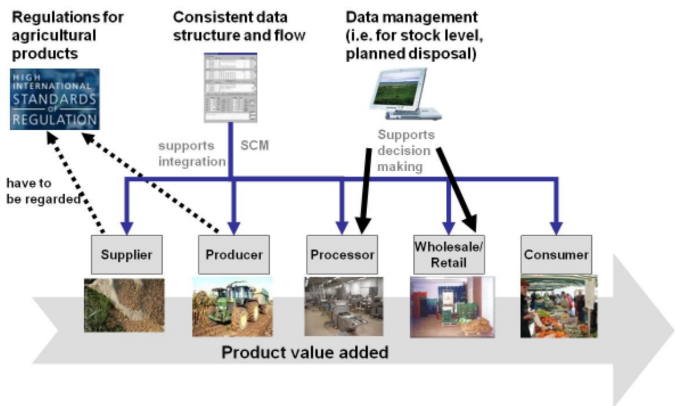

Figure 5: Supply Chain networks' functionalities (B. Bemeleit, 2007)

A concept supporting the synchronisation of flows is the intelligent Cargo concept. It is aiming at "*To build an information services platform centred on the individual cargo item and on its interaction with the surrounding environment and the user" (EURIDICE, 2009).*
The intelligent cargo concept is based upon 3 basic and 3 advanced capabilities listed in table 1 below.

Capability		**Intelligent Cargo**
Basic	Self-identification	- Global identification provided by public domain services. - Cargo is able to self-identify through a common infrastructure, accessible to field users, vehicles and back-office. - Dynamically selected level of detail (package, pallet, container).
	Context detection	- Context determination provided by public domain services. - Common infrastructure, providing context data (identification details, location, time) to authorized users.
	Access to services	- Common infrastructure, providing access to services to authorized users or systems interacting with the cargo.
Advanced	Status monitoring and registering	- Status data are available in real time through the service infrastructure. - Status data are contextualized and integrated with the other cargo information services.
	Independent behaviour	- Cargo is able to invoke services and start processes autonomously in response to predefined events.
	Autonomous decisions (Intelligent agent)	- Cargo has decisions making capabilities and is able to choose services to invoke according to circumstances.

Table 3: Intelligent Cargo Capabilities (EURIDICE, 2009)

Hence, we use the term Intelligent Cargo if an object offers at least all basic capabilities in table 1 and communicate with its environment. In the most advanced cases such an item needs to be able to process and execute decision autonomously (Böse and Windt, 2007). The concept foresees not only the implementation of RFID and sensors, also other basic technological components needed for the realization of intelligent item/cargo is "service oriented architectures (SOA) and interoperability platforms for data interchange and collaboration between business partners mobile technologies and global positioning systems. Equally important is the availability of standards addressing all the aspects of cargo identification and management. Figure 6 shows the improved synchronization of the information and material flow by the implementation of Intelligent Cargo Concept.

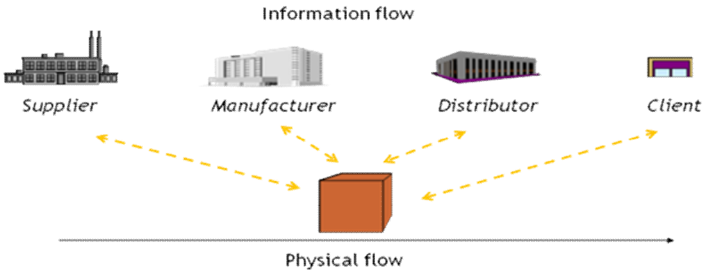

Figure 6: Material and information flow applying the intelligent cargo concept

The question which arises is why such concept as the Intelligent Cargo concept does not penetrate the supply chain, even though it seems clear that it will reduce the challenges each stakeholder deals with every day. To some extent this is caused by the adoptions barriers (EURIDICE, 2009). Adoption barriers are related to the cost, effort and information system requirements which the implementation causes, but it is also caused by the uncertainty the decision makers have regarding the return on investment and on the impact the implementation will have.

The Intelligent Cargo concept induces a paradigm shift, which main changes can be seen in table two.

	Current paradigm	Intelligent Cargo
Data origin	User or back-office generated	Item/sensor generated
Interaction paradigm	Organization-to-organization	Thing-to-thing
Data processing	Centralized at organization level	Distributed, may start at object level
Communication support	Predefined communication channels	Self-configuring combination of local and global communication resources
Data interchange semantics	Mutually agreed with each partner or between trade community members	Globally established, for any-to-any ad hoc exchanges

Table 4: Intelligent Cargo Paradigme (EURIDICE, 2009)

The paradigm shift leads to large organisational changes and thus leads to changes in an employee's working environment and mostly, due to the past experience of many employees, organisational changes often leads to outsourcing or labour reduction. Hence, most employees are quite sceptic to any changes in their working environment, esp. if they cannot overlook the impacts on their own situation. In the case of the implementation of the Intelligent Cargo concept, the authors have looked at how it might be possible to reduce the adoption barriers by training the employees by improving their awareness on Intelligent Cargo as well by training specific skills.

Table 1 lists benefits which might be achieved and the analyse under which circumstances these can be achieved, it becomes clear that the employees being in touch with the Intelligent Cargo need to have basic knowledge on the technologies in use. Secondly, by looking on table 2 describing the Intelligent Cargo capabilities, it appears that training also need to comprise awareness raising topics regarding organisational changes and their impact on the supply chain. Thus, it can clearly be stated that four main topics needs to be addressed:

- Intelligent Cargo technical aspects (RFID, GNSS, configuration of ICT services)
- Intelligent Cargo services (how to apply and implement them)
- Organizational issues (re-engineering, the use of KPI, SCM, information management)
- Business and enterprise network related (management of logistics networks, customs regulations, unit documentation)

The question is how to mediate this awareness in such an environment that the employee and the organization as such can reduce their personal barriers at on hand side, but also being able to assess both the positive and negative impact the implementation of Intelligent Cargo may have on the supply chain.
The next section will look at under which circumstances the use of serious games will support the implementation of the Intelligent Cargo concept.

RESEARCH APPROACH

Preparing an organization (i.e. producers, logistics services providers, 4PL, Authorities, Infrastructure service providers etc.) for the new requirements, which are requested by the use of Intelligent Cargo solutions, is to a large extent a question of increasing the awareness and knowledge of the concept among the employees. However, this has to be done in such a way that they do not feel threatened. It is very difficult to mediate more practical skills by lectures. In such case, the use of experiential learning methods has been proven to be very efficient (Windhoff, 2001, Schwesig, 2005). It seems therefore quite likely that the use of serious games could be a suitable approach for increasing the awareness of Intelligent Cargo concept, since this also offers a risk free training environment. Serious games have been used for mediate skills on complex systems for several decades in the military education (Hays, Singer, 1989) and since the 1950's there is an increased use of games also for civil purposes (Wolfe, Crookal, 1998). Serious Games are mostly used for teaching purposes. In the area of logistic, serious games have been developed for mediating skills on insulated problems like the bullwhip effect on understanding the supply chain as such or for improving the collaboration among employees working in supply or production network. These are only a few examples but it illustrates the large variety of applications, used for mediation specific skills and have been proven to be quite effective (Windhoff, 2001). The implementation of the intelligent Cargo concept requires that the game will support a paradigm shift, i.e. it needs to increase the awareness of a concept not implemented yet. Hence, in order to get an overview of available serious games, another desk top research combined with a SWOT analysis was carried out. The first desktop study carried out showed that there are some games supporting different elements of needed for the implementation of Intelligent Cargo Concept, but we did not find any game aiming at supporting the understanding of a paradigm shift.

The analyses of games were based on public available information. The games analysed are either developed for distributed and cooperative productions or for supply chains, but also games focusing at on specific logistic topic (like movement of goods in the harbour or enterprise), were analysed. In order to look at the relevance of different games for specific topics being relevant for the Intelligent Cargo, we first identified these games by applying and extending a structured taxonomy for the description of serious games called the serious game genome (Hunecker, 2009). This allows us to see the thematic relation between games, and consequently to assess its relevance for Intelligent Cargo topics.

Most games analysed were business games, with target group decision makers or students. It was not the intention of the analysis to find a single game supporting the implementation of Intelligent Cargo, the focus was to assess under which circumstances the use of serious game as mediation medium would lead to better learning result than a traditional course, either as e-learning or on-site course. Thus, the assessment is hence based on the experience other trainers have had in using specific games. The problem that arises by using this approach is that there is no comprehensive theory about learning and knowing through gaming and simulation due to competing epistemologies

(Klabbers, 2003). However, experiential learning theory has long been the inspiration for building computer based learning environments (Lainema, 2003). Educational games and simulations are experiential exercises (Gredler, 1996), and experiential learning relates specifically to the learning of adults (Cheetham and Chivers, 2001) and some results on learning outcomes are available. Evaluation of learning results requires that an individual has been exposed to the situation where learning was intended to take place.

There are some different approaches for the evaluation of learning outcomes in games. Kirkpatrick's model is a four level process used to determine the effectiveness of training. Kirkpatrick (1996) has defined the four levels of evaluation as follows: 1) Reaction, involves measuring how participants react to or feel about a training program. 2) Learning, measures the extent to which participants' knowledge, skills, and attitudes change as a result of training. 3) Behaviour, examines the extent to which a change in behaviour has occurred as a result of attending a training program. 4) Results can be defined as the final results that occurred due to students attending a training program. Results may be related to for instance change in his skills and competencies, in this case on the Intelligent Cargo Concept and related areas.

FIRST FINDINGS

The SWOT analysis showed that the learning outcome by using computer based games is higher if the learning topic is on complex situation and the impact of personal behaviour. Also the analysed board games showed quite good results here. Most of the games are simulation based. Important for the learning outcome is thus that the player understands the simulation environment and that the reduction of the complex world is sufficient. Several games addressing too many learning goals or offering too many alternatives to the players had a lower learning outcome than the more focused once. Assessing the learning outcome of using games for training specific skills like how to handle goods or to operate devices is very low by using computer based serious games. However it has to be mentioned that we hardly found any such games. Most of what we found supporting the mediation of such skills with a high learning outcome were mostly traditional vocational training courses on the concept training on the job or in an equal workshop setting. The same is true for purely technical skills. Regarding the pure mediation of professional skills, like knowledge on different technologies etc. the highest learning outcome was by offering traditional courses (reading books was not considered), however, by the application those technologies, the games scored higher than traditional courses.

Taking into the account the cost and the efforts needed for developing serious games, it can be stated that a serious game will deliver the best solution on topics concerning the awareness raising and visualisation of the impact the implementation of Intelligent Cargo will have both on organisational as well as individual level since this will allow a reduction of the complexity of the simulated working environment and also, depending on the design offer possibilities to take different roles.

NEXT STEPS

Based upon the outcome of the SWOT analsysis, we have started the design of a game called Intelligent CARGO impact game.

The main objective of the EURIDICE Intelligent Cargo impact game is to visualize both advantages and challenges of implementing the Intelligent Cargo solution in a supply network or in part of the supply network.

The learning objectives of this game are:

- To increase the awareness on how the EURIDICE IC will have an impact on organisational structure.
- To understand the impact of the paradigm shift which the implementation of IC causes on the supply chain
- To be able to identify the needed organisational changes as well as to estimate the ROI of this.
- Get an overview of applicable services and under which circumstances their implementation will be useful.

It will be scenario based simulation game, based upon the different pilot scenarios covering all stakeholders typically participating in a supply chain. It will be event triggered and in order to reduce the complexity for new users, a predefined scenario based on a generic, but simple case will be implemented. The first prototype will be available by the end of July for assessment.

CONCLUSION

This paper discusses under which circumstances it seems appropriate to use serious games. The implementation of the Intelligent Cargo concept leads to the adoption of advanced ICT and the use of technical devices. A correct handling and operation is very important for the efficiency of the solution, but developing a computer based game in which the user can apply and use the devices, will be too costly and probably inefficient, thus the paper discusses when to use computerised and non-computerised games as well as the limitation of the use of serious games. The SWOT analysis has shown that the use of serious games is appropriate if the focus is on awareness raising or mediation of behavioural impact in complex environment.

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REFERENCES

Baalsrud Hauge, J.; Thoben, K-D(2007): Applying Serious Games in the Education of Engineers In: Learning with Games. 24-26 September 2007, Sofia Antipolis, Frankreich. S. 539-546

Böse F., and Windt K.: "Catalogue of Criteria for Autonomous Control in Logistics." In *Understanding Autonomous Cooperatoin and Control in Logistics - The Impact on Management, Information and Communication and Material Flow*, by Michael Hülsmann and Katja Windt, 57-72. Berlin: Springer, 2007

Cheetham, G.; Chivers, G.(2001): *How Professionals Learn in Practice: An Investigation of Informal Learning Amongst People Working in Professions.* Journal of European Industrial Training (2001) 25/5 pp. 248-292.

EURIDICE Project White Paper (2009).Version Nov 09 Available: www.euridice-project.eu

European Commission DG INFSO(2006) "ICT for Transport" Strategic Research Agenda.

Gredler, M.E.(1996); *Educational Games and Simulations: A Technology in search of a (Research) Paradigm.* In Jonassen, D.H. Handbook of Research for Educational Communications and Technology. New York: Macmillan.

Hausladen, I. et al (2008). Logistik-Weiterbildungsbedarf der Wirtschaft im Raum Leipzig,2008

Hays, R. T.; Singer, M. J.(1989): Simulation fidelity in training system design: bridging the gap between reality and training. New York.

Hunecker, F.; Baalsrud Hauge, J.; Duin, H.; Thoben, K-D. (2009): Towards the Serious Game Genome – Designing a Taxonomy for Serious Games. In: Proceedings of the SIG Workshop 2009

Jüttner U.: "Supply chain risk management", *The International Journal of Logistics Management, 16, 1, 2005,120-141.*

Kirkpatrick, D.(1996): Evaluating training programs: The four levels. (1996) San Francisco: Berrett- Koehler Publishers.

Klabbers, J.H.G., *Interactive learning of what?* In Percival, Godfrey, Laybourn, Murray (2003, eds.) The International Simulation and Gaming Yearbook, vol. 11, pp. 257-266. Napier University, Edinburgh, Scotland.

Lainema, T.(2003): *Enhancing Organizational Business Process Perception - Experiences from Constructing and Applying a Dynamic Business Simulation Game.* (2003) Turku, Turku School of Economics and Business Administration.

Pfohl, H.C.:. „Risiken und Chancen: Strategische Analyse in der Supply Chain“, *in: Pfohl, H.C. (Hrsg.), Risiko- und Chancenmanagement in der Supply Chain, Darmstadt, 2002, Seite 1 – 50*

Riedel, J, Pawar K, Torrini S., Ferrari E.(2007): "A Survey of RFID Awareness and use in the UK Losgistics Industry"*, LDIC2007 Dynamics in Logistics: First International Conference. Proceedings.* Heidelberg: Springer, 2007. 105-115

Schwesig, M.(2005): Development of a web based management simulation of knowledge exchange in networked manufacturing organisations, BIBA Reihe Band 54; Mainz Verlag; Aachen, 2005.

Sørensen L. B.: "How risk and uncertainty is used in supply chain management", *a literature study, Copenhagen, 2005*
Waters S.,Rahman S.(2008): "RFID in Supply Chains: Literature review and an agenda for future research". *In Pawar, K. S., Lalwani, C.S., Banomyong, R.: Conference Proceedings of the 13th intenational symposium on Logisics, ISL 2008*, Centre of concurrent Enterprise, Nottingham University Business School. Nottingham 2008, 418-425

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. Bremen

Wolfe, J.D.; Crookal, D.(1998): Developing a Scientific Knowledge of Simulation/Gaming. In: Simulation and Gaming.

Wolters Kluwer (2005): "What It Costs to Manage Collaborative Logistics", Eye For Transport Research Services.

CASE STUDY ON IT OUTSOURCING BY A LOGISTICS SERVICE PROVIDER – AN INTROSPECTION OF THE OPPORTUNITIES AND CHALLENGES FACED

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ABSTRACT

Outsourcing has become one of the defacto standards of managing business by many organizations. In logistics industry this is the name of the game. Traditionally only shippers were outsourcing their logistic needs to LSPs (Logistics Service Providers). By which these LSPs would manage the shipper's end to end logistic needs. These things happened because shipper's wanted to reduce their operational costs.

As the LSP industry evolved these LSPs also started focusing on cost reductions and also evaluated outsourcing as an option. LSPs found that IT as a function which can be outsourced since they didn't want to build competence in a non core area. In simple terms IT is to LSP what Logistics was to Shippers that is non core functions in their organization's value chain.

The LSP Organization presented in this Case Study decided to go for Outsourcing of its IT needs since IT was a more a burden than being a beneficiary. Its IT infrastructure was highly fragmented and was very out dated. Due to which its IT infrastructure was unable to cope with its newer operational offerings to its clients in short its IT lacked the required Scalability and Flexibility.

The LSP Organization went through a rigorous selection process identified a vendor to whom it offered the Outsourcing Contract for its IT.

INTRODUCTION:

In this case study the details of our outsourcing experience are discussed. The client's business nature is discussed and then why and how of outsourcing is then detailed. The benefits experience by our client is shared and at last we discuss on how we plan to take forward our relationship with our client

LSP OPERATIONS AND ROLE OF IT:

Logistics Service Providers play an important role in managing the Supply Chain of Shippers who is their customers. They provide various services from basic services like transportation, warehousing; value added services like packaging, kitting, assembly etc.

Apart from these they also provide Customized Solutions which result in customized operations for each of their customers. These customized operations result are driven by SOPs (Standard Operating Procedures) per core operation for the customer. Figure 1 shows the scope of operations for a Logistics Service Provider.

Without the application of IT into their operations it would difficult for LSPs to provide customized operations. As information systems control the operational flow to level that is required. So the drawback is that most COTS (Commercial Off The Shelf) systems would not fit directly or in some cases they even require customization levels greater than 20%. So they have more home grown systems than those procured from the market. But off late the trend has been that there are new as well as existing providers who are now offering IT for LSP operations. But still this is a long way to go as far as fitment and accuracy is concerned.

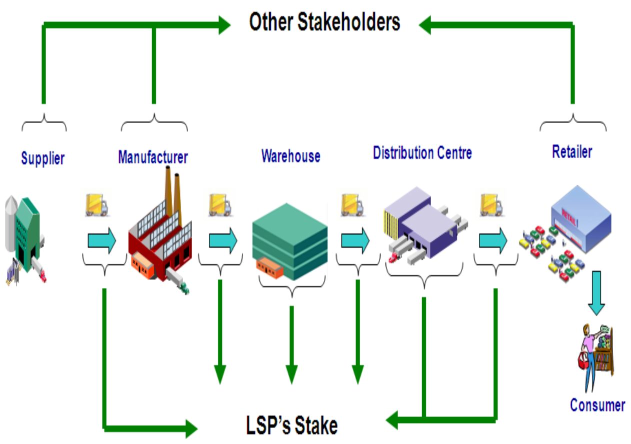

Figure 1: Operational Scope of a Logistics Service Provider

OUR CLIENT'S OPERATIONS:
Our client is a billion dollar organization providing international, non-asset-based supply chain services and solutions. They are present in more than 103 countries around the globe and they provide services like air and ocean freight forwarding, contract logistics, customs brokerage, distribution, inbound logistics, truckload brokerage and other supply chain management services.

Our client has grown inorganically over the period by acquiring companies present in different countries and is in the space of providing logistics services. They employ more than 11,800 people in their different facilities across the world. Their key operations are

Freight Forwarding – They operate as an indirect carrier for their customers or as an authorized agent for an airline or ocean carrier. And they operate as a direct carrier if there is significant transaction volume. They provide other support services export documentation if required by their customer

Customs brokerage is provided at the import side if they are appointed by their customer to carry out this operation. Contract Logistics and Distribution – They provide services like warehousing and distribution of goods and materials based on their customer's inventory requirements.

REASONS FOR OUTSOURCING - IT OUTSOURCING MODELS:
Our client has been having a long standing relationship with us for a period of over 3 years during which they were providing us work at different levels of outsourcing. Our initial stages were related to Out-Tasking Model where we were performing Integration related work. We looked after the integration needs between their discrete systems. Apart from Out-Tasking we have also performed Staff augmentation for certain technical gaps during our relationship initiation days.

Later our relationship with our client progressed during which we entered into Project based outsourcing model. We development and implemented a system for exchanging shipment documentation between their different operational units. During our relationship with our client they experienced our commitment and quality of our delivery.

During this point of time they realized that their IT Landscape having 400 plus systems consisting of a multitude of non-standard and diverse systems. They managed their IT as silos in their different operating regions. These systems were increasingly becoming difficult to manage. They decided to enter into an outsourcing agreement under the Manage Services Model.

PRE- OUTSOURCING SCENARIO - IN HOUSE IT:

Our client had separate IT sub organizations for each region. This resulted in duplication in the systems used and all their procurement / purchase decisions were only decided by that respective regional IT organization. Though they performed near similar operations they had always more than one system that performs their core business operations. To give an indication complexity here is an example that for warehouse operations performed within the organization they have more than 60 similar systems.

The new IT leadership found that there is no synergy and also lack of optimal utilization of the resources within the entire organization. They also found there was poor IT documentation and all regions didn't follow a standard IT development and maintenance process. In short the different regional IT organizations were regional driven and people dependent. This resulted in lack of flexibility in IT to support operations and different customer requirements. The client leadership envisioned consolidation of the organization to give a single face to their customers. The IT outsourcing was step in that direction.

THE OUTSOURCING APPROACH & PROCESS:

Our client's internal leadership engaged us to assess the current situation. We employed a team of consultants to assess the application inventory and thereby provide the CIO's team visibility and metrics in terms of the portfolio of applications & technologies and number of people supporting to its vast and complex IT infrastructure.

Based on this assessment and a post analysis made by our client, it was decided that our client would outsource 30% of their systems which were spread across the different regional IT organizations. Among the outsourcing requirements were that we had to rebadge a certain number of the client's employees.

Since we had vast experience in handling "Managed Services" based outsourcing model using our copyrighted / proprietary framework MASCOT™. We initiated the outsourcing process taking knowledge on the identified systems for the existing IT teams that were managing these identified systems. For this process we used our Copyrighted / proprietary Knowledge Acquisition methodology to manage the entire process. We faced immense hurdles in acquiring knowledge since many employees were beginning to lose their existing positions in those regional IT organizations. Only for few of the systems did we receive complete documentation and knowledge from the respective IT Team. Few of the employees who felt that their future is at stake and left the organization giving very short notice which resulted in impacting "Business as Usual". We reacted by sending our senior technical employees who can understand those systems at a short notice and can manage the show.

The entire knowledge acquisition process took us 10 months to complete as our teams visited different geographies and interacted with the application teams in the different regional IT organizations. The composition of the Teams involved Business Analysts, Technical Leaders who managed the knowledge acquisition process and a Technical team that acquired the knowledge on the systems. We also had an team in offshore who supported this knowledge acquisition process. We kept the entire knowledge acquisition process transparent using our internal Project Management System which is driven by our project management practices. Using the Project Management system we managed escalations between our teams and our client teams.

POST OUTSOURCING SCENARIO - BENEFITS & RESULTS
Once the knowledge acquisition process was completed for all systems and all regions we established Service Desk teams by application and region to support these outsourced applications. All the business users who are using these outsourced applications and log their issues both by severity and criticality. These again had different service levels with service level have a specific service time window. These service levels were part of our SLAs present in the contract to manage this entire outsourcing agreement. Since we didn't complete knowledge for most of the systems we had an initial observation period wherein we will not be penalized subsequently we entered into the actual enforcement of the contractual agreements.

Once this outsourcing was completed our client initiated its internal IT reorganization and started consolidating their IT operations across the different regional IT organizations by bringing all of them under one umbrella IT organization.

There are now practically less than 5% system down times affecting business which is being worked to bring it to less than 1%. All existing bugs technical and functional are being fixed now at a lesser cost and with quicker turn-around time. All outsourced systems today have documentation. Based on our experience we had suggested and implemented various measures related to Application Optimization and reduction of redundant applications.

The TCO of the outsourced systems have come down resulting which the client's leadership which has reported in a net savings of more than USD 5 million.

CONCLUSION - NEXT STEPS:
This outsourcing agreement has helped in increasing the confidence in us which has resulted in the client offering to partner with us. We are being considered even more in their IT consolidation initiatives which are good for us to serve them in a more efficient manner. We have proposed significant solutions that would have direct impact in adding efficiency while lowering the cost of their operations. And these are at their initial negotiation stages for their feasibility in all perspectives. Today in certain areas we are managing only systems and not their entire process. Achieving would this would be our milestone and would help us give still better ROI for investments in IT.

REFERENCES

1. HCL Proprietary Project document Repository

2. Marcia Robinson and Ravi Kalakota (2004), Offshore Outsourcing: Business Models, ROI and Best Practices

3. http://www.executivebrief.com/outsourcing/outsourcing-models/

TOWARDS THE EXTENDED ENTERPRISE: CLARIFYING PARADIGMS AND CONCEPTS IN SUPPLY CHAIN MANAGEMENT

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INTRODUCTION

Although business interest in the concept of Supply Chain Management (SCM) has augmented since the 1980s when companies first recognised the gains of collaboration inside and outside their boundaries, SCM has been ill-defined, and there is no consensus on what the term means (e.g. Mentzer *et al*., 2001). The purpose of this paper is to identify the important paradigms in SCM theory and practice, and explore how they relate one another. Moreover, the paper aims to develop a more complete understanding of the different paradigms and concepts of Supply Chain (SC) collaborative forms, and in particular the recent paradigm shift of the Extended Enterprise (EE). The paper provides a review of the evolution of SCM theory and practice and its current pinnacle, namely the EE, as well as offering clarification between the main SCM paradigms and concepts. The literature review assists in identifying gaps in existing knowledge that should assist the emergence of future research questions.

DEFINING THE SUPPLY CHAIN

Although nowadays there is a considerable degree of agreement between sources in the literature, absolute consensus on defining the SC remains elusive. Mentzer *et al*. (2001) defined the SC as "a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer". Such a definition could be classified as 'organisation-centric', as it is concerned with the participant organisations, i.e. the entities or elements that constitute the hubs and nodes for adding value in the supply process. Organisation-centric definitions constitute the majority in the literature and focus primarily on the 'players' involved in a SC and the management of their relationships to achieve a smooth flow of material and the delivery of the final product to the end customer. Definitions of SC with an organisation focus are provided, among others, by Simchi-Levi *et al*. (2008) and Chase *et al*. (2007). Other SC definitions are primarily concerned with the activities and processes that ensure the flow of material and the delivery of the final product to the end customer. For example, in their more process-centric approach, Schary & Skjøtt-Larsen (2003) defined the SC as "the entire set of activities involving the organisation and flow of material and other resources to produce and deliver the product to the final customer". Definitions of SC with a process focus are provided, among others, by Heizer and Render (2011) and Slack *et al*. (2010). Although constituting the minority in the literature, there are also definitions capturing both the 'organisation-centric' and 'process-centric' view: for example, Stevenson (2007) argued that a SC is "A sequence of activities and organisations involved in producing and delivering a good or service".

The previous discussion perhaps suggests a low-key debate in the academic literature, as to whether SCs are best seen as 'organisation-centric' or 'process-centric' in their focus. Nevertheless, all definitions converge to the key points that a SC is built around adding value for the customer, and its aim (either through the management of the relationships, or through the management of the activities) is to serve the final customer. Based on the previous discussion, for the purposes of this paper, the SC has been defined as *the set of activities and relationships that link companies in the value-*

creation process, in order to provide the final customer with the appropriate value mix of products and/or services.

DEFINING SUPPLY CHAIN MANAGEMENT

In an attempt to classify the different SCM definitions, Mentzer *et al*. (2001) suggested that they can be grouped into three categories: a management philosophy, a set of activities to implement the management philosophy, and a set of management processes. Nevertheless, to explain the variability in the definitions, the time dimension in SCM concept development should be considered. Although there is no universally agreed definition of SCM, the idea of process integration among the SC members is inherent in the concept of management of the SC. Early SCM definitions focused on the physical movement of goods, i.e. the total flow of materials from suppliers to end customers (Jones & Riley, 1987) and already referred to "an integrating philosophy to manage that total flow of a distribution channel from supplier to the ultimate user" (Ellram & Cooper, 1990). Almost all the earlier definitions agree that SCM should focus on integrating key business processes from original suppliers through to end user (Monczka & Morgan, 1997), to ensure the flow of products/services in order to deliver (superior, if possible) value to the end-customer in a profitable way for the SC members. Such definitions imply the existence of supporting infrastructure links (transport, communications) and other means/facilitators to connect companies within the SC, but they did not suggest a long-term viewpoint to effectively manage the SC as a whole.

Later definitions tended to adopt a more strategic perspective of SCM, by focusing on long-term performance of the whole SC. That may reflect the period during which SCM emerged as a sub-discipline in its own right, and became distinguished from the field of Logistics. The terms SCM and Logistics have often been confused and perceived as overlapping (Lummus *et al*., 2001) or even synonymous (Lysons & Farrington, 2006), and as already discussed, early attempts to define SCM focused on the flow of material and information, creating some confusion as to their difference. Logistics coordinates the flow of material and information across the SC making it an essential trigger for SCM (Harrison & Van Hoek, 2008), but today it is considered as a subset of SCM. For example, the Council of Supply Chain Management Professionals (CSCMP) states that SCM "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities" (CSCMP, 2010). Following this theme, SCM has been defined as "the systemic, strategic coordination of the traditional business functions within a particular company and across businesses within the SC, for the purposes of improving the long-term performance of the individual companies and the SC as a whole" (Mentzer, 2000). Nevertheless, there has been recent debate and various views as to whether SCM and Logistics constitute sub-sets of one another, or co-exist, or indeed whether SCM simply constitutes a re-labelling of Logistics (Larson *et al*., 2007).

It became evident that the development of effective SC relationships was crucial for the management of the flow of materials and information across the SC (Handfield & Nichols, 1999). Further, it was increasingly suggested that competition no longer took place between companies, but between entire SCs (e.g. Dyer, 2000). Companies increasingly aimed to compete through their SCs, stressing the need to manage the SC as an integrated system in order to ensure effective support against the competitive forces in the market (Hill, 2000). Hence, it was advocated that to achieve effective SCM requires that all SC members (i.e. retailers, manufacturers, and intermediaries) coordinate with each other (Xu *et al*., 2000). It was argued that SCM should follow a more holistic approach, by extending the idea of functional integration beyond the boundaries of the single company, to include all firms in the SC. To improve SC competitiveness all members must assist each other (Min, 2000), stressing the idea of mutuality among the SC members, as having a positive impact on the effectiveness and efficiency of the whole SC. Christopher (2005) revisited this 'mutually-beneficial' perspective by arguing that SCM stresses the need to manage the relationships among the SC members to achieve a more profitable outcome for all. Subsequently, he defined

SCM as the management of the SC relationships both upstream and downstream in order for the SC as a whole to deliver superior customer value at lower cost. Finally, there are authors who have recently taken the relationship approach to the partnership level when defining SCM. For example, Harrison & Van Hoek (2008) defined SCM as "planning and controlling all the business processes – from end-customer to raw material suppliers – that link together *partners* in a SC in order to serve the needs of the end-customer". Occasionally, the concept development of SCM is evident in the definitions provided by the same authors through the years (see Slack *et al.*, 1998; Slack *et al*., 2010).

This discussion on the development and the pluralism of SCM definitions suggests that it takes time for a definition to develop and mature in order to reflect the actual business practice, which is itself evolving, partly under the influence of academic thinkers. From the earlier focus on managing activities and the flow of material, the more recent approaches focus also on managing the whole SC as one system (i.e. all members and the mutually beneficial relationships among them) with a clear strategic intent. This illustrates the need for academic authors, as well as managers, to keep abreast of current developments in the definitions, philosophies, methods and technologies used to manage the SC in an effective and efficient way.

THE EMERGENCE OF THE SUPPLY CHAIN PARADIGM AND THE VALUE CHAIN

To understand the development and nature of SCM, it is necessary to appreciate the reasons that drove its conceptualisation, as well as its subsequent development in the SC-related business paradigms. As business practices, SCs have existed as long as commerce and manufacturing, but have not, until relatively recently, been the subject of formal study. Ketchen & Giunipero (2004) have traced the modern SC concept in Henry Ford's SC some 85 years ago, which consisted of a vertically integrated set of wholly owned suppliers. However, the evolution of the SC and SCM concepts during the last two decades has been substantial, involving a paradigm shift that has developed the manager's awareness towards more subtle concepts of co-operation and competition, since co-operation nowadays has broadened in scope and takes place within the whole SC (Spekman *et al.*, 1998). Nowadays, the contribution of suppliers to the manufacturer's performance in several major areas has been acknowledged (Szwejczewski *et al*., 2005), and that increases the interest in SCM further.

In one of the first academic papers on SCM, Houlihan (1985), focusing on manufacturing and distribution strategies, stressed the importance for international companies of evaluating the way they managed their SCs. Manufacturing strategy was traditionally concerned with the internal operations of manufacturing companies (Cagliano *et al*., 2006), but Porter's (1985) seminal Value Chain concept underpinned the shift to the SC metaphor, by reconceptualising a firm's strategic capability, with a focus on analysis of value and of the inter-connection among activities (Graham & Ahmed, 2000). A global recession in the late 1980s and early 1990s made companies re-evaluate how they could add value and reduce costs (Harland *et al*., 1999) and the Value Chain model was widely adopted. However, critics of the model in relation to the SC domain have pointed out that the so-called 'primary activities' should also include the activities of customer service and distribution, and the model has also been criticised for describing the procurement activity as being a 'supporting' one (Morden, 2007).

Nevertheless, the contribution of Porter's Value Chain to the shift towards the SC metaphor is of paramount importance in realising the idea of interconnection among SC members, and the term Value Chain has been used interchangeably, or as an alternative, with SC (Lysons & Farrington, 2006). Yet, the SC and Value Chain concepts have been clearly distinguished in the literature and their exchange relationships described. The interest in the integration of purchasing, manufacturing and distribution activities promoted SCM as a new business paradigm; an integration facilitated by information technology (Shapiro, 2004). Increased national and international competition, which many companies started to face in the 1990s (Dangayach &

Deshmukh, 2001), augmented the need for strategic alliances between them. In the late 1990s, it became evident that competition was increasingly based on networks of co-operating companies (Spekman *et al.*, 1994). This 'new competition' included global networks, with agile companies at their core able to respond fast to changing market requirements (Spekman *et al.*, 1998). The internet boom of the late 1990s conveniently provided the technological foundation for cost effective, immediate and real-time information sharing among SC members, assisting partnerships and leading to a further shift towards a network metaphor, leading authors to characterise the SC as a *network of companies* that create value through the transformation of raw materials into final products (e.g. Handfield & Nichols, 2002), or simply refer to the Supply Network instead (e.g. Slack *et al*., 2010). The shift to the network paradigm promotes the consideration and understanding of competitive and cooperative forces, helps in identifying particularly significant relationships, and encourages a fundamental focus on long-term issues (Slack & Lewis, 2008), essentially suggesting a new way of 'doing business' both upstream and downstream. The paradigm shifts of the network metaphor assisted in reflecting the way organisations deal with their customers and suppliers and the level of integration necessary for achieving competitive advantage. As the network metaphor evolved, however, a further paradigm shift towards a concept called the Extended Enterprise (EE) was also emerging.

THE EXTENDED ENTERPRISE

Coined by Chrysler (Dyer, 2000), the term 'Extended Enterprise' has been defined as "the entire set of collaborating companies, both upstream and downstream, from raw material to end-use consumption, that work together to bring value to the marketplace" (Davis & Spekman, 2004). Browne & Zhang (1999) identified three key characteristics of the EE: (*a*) the manufacturing company focuses on the core business and outsources the non-core business to suppliers and service providers, which increases their mutual dependence and enhances their competitive capability; (*b*) the relationships formed are long-term with partners being treated as equals; (*c*) to support the activities of the integrated members and to provide them with seamless and effective information exchange, inter-organisational methods, processes and technologies are established. The EE, then, is an advanced and sophisticated form of SC. It extends the notion of SC integration (Davis & Spekman, 2004), focusing on the product value chain and taking responsibility for the entire product life cycle, with its member organisations strategically networking their activities and combining their competencies and capabilities to create new unique competencies (Browne & Zhang, 1999). Within the manufacturing EE environment, customers looking for customised products and suppliers may enter the manufacturing process and contribute with their competencies and capabilities in the design, development, manufacturing and maintenance of a unique product (Browne & Zhang, 1999).

Shared new product development, an essential driving force in the formation of the EE, denotes sharing of technical expertise and often of commercial risks (Boardman & Clegg, 2001). Within the EE paradigm, sharing risks and rewards among the partners, technology sharing, communication channels and cross-functional teams constitute essential ingredients to enhance collaboration and achieve a common strategic intent (Spekman & Davis, 2004). Indeed, collaboration may go further - staff from participant organisations in the EE's should engage in common decision-making processes in order to satisfy the customers' diversified demands, which will lead them to innovate not only in products, but also in processes (Dyer, 2000; O'Neil & Sackett, 1994). Owen *et al*. (2008) suggested that to enable collaborative innovation, apart from aligning strategic vision and innovation goals throughout the organisation, it is necessary to manage boundaries to facilitate collaboration between organisations. They also argued that as well as commitment, an essential factor to co-ordinate and systemise collaborative innovation throughout the EE is the setting up of structures and processes regarding operations, technology and governance. Hence, the formation of an EE takes SCM to the next level, as it demands a focus on aspects far beyond the workflow and material flow considerations (Spekman & Davis, 2004). The EE must aim to develop lasting co-operative relationships, responsible for the development and maintenance of a product throughout its life. O'Neil & Sackett (1994) argued that knowledge and trust are the vital resources in the EE.

Consequently, the successful formation of the EE requires a fundamental change in the power configuration among the participant companies (Bititci *et al*., 2005). Price still plays an important role in the business relationships among the EE members, but value is often created in ways that make price a secondary consideration, as the main emphasis is on innovation and information (Spekman & Davis, 2004). Part of the significance of the EE concept, as distinct from the usual SC or subcontracting relationship, is that it is based on the idea that firms are linked as learning organisations (Sehdev *et al*., 1995). To develop innovative products requires the development of skills and processes that enable knowledge integration (O'Neil & Sackett, 1994). The EE, then, is a knowledge-based collaboration, with information and communication technologies assisting in linking and developing the practices of the member organisations, to minimise the negative effects of geographical separation (Bititci *et al*., 2005; Tonchia & Tramontano, 2004), to create customer value in a spirit of mutuality for its members (Spekman & Davis, 2004).

The EE must therefore incorporate an information and organisation network, extending both inside and outside the company's boundaries. It constitutes both an operational network (delivering products or services) and a community of practice, whose members learn and develop skills by constantly exchanging knowledge (Bititci *et al*., 2005, Tonchia & Tramontano, 2004). At an operational level, the EE should utilise state-of-the-art SC information systems to allow for real-time exchange of information throughout the whole network through enterprise portals and other Internet-enabled technologies (Burton and Boeder, 2003). The implementation of these technologies assists in the realisation and subsequent support of the EE, as apart from the necessary operational co-ordination between EE partners, communication among them is a critical issue and affects behaviour (Spekman & Davis, 2004). As suggested above, the EE should be founded on long-term trust, as the basis for fostering commitment (Kwon & Suh, 2005) and mutually dependent relationships among SC partners (Browne & Zhang, 1999). Trust (i.e. one party's confidence that another party in the exchange relationship will adhere to commitments and will not exploit its vulnerabilities) creates mutual dependency and esprit de corps which holds the extended SC together (Dyer, 2000). Based on the previous discussion and drawing upon Bititci *et al*. (2004), the EE is defined as *an advanced form of a SC in which a focal organisation extends the notion of SC integration to the entire set of collaborating companies, both upstream and downstream, based on a philosophy of long-term mutual benefits, in which member organisations strategically combine their strengths (core competencies and capabilities) in a highly committed inter-organisational fashion. Members aim to create new unique competencies and bring value to the marketplace in the form of the development of a new product and/or service.*

Nevertheless, some confusion is evident in the literature, both in defining SC collaborative structures relevant to the EE and in defining the EE concept itself. There are several concepts closely related to the EE, and confusion may also arise when some authors advance similar concepts under different names, such as the Virtual Enterprise (VE) (Tonchia & Tramontano, 2004). For example, while the VE is also characterised by transparency achieved through IT-facilitated information sharing, it typically involves shorter-term relationships between partners, hence it has been characterised as a "quick-creating and quick-dissolving organisation" (Browne & Zhang, 1999). Moreover, the VE is usually a small (in terms of permanent staff) company, which outsources the majority of its processes and services to other (again often small) companies. A further confusion may arise with the 'Extended SC' concept. Mentzer *et al*. (2001) identified three types of channel relationships within the SC, namely 'Direct SC', 'Extended SC', and 'Ultimate SC'. Developing an Extended SC suggests advanced forms of integration, going beyond first-tier or immediate suppliers and customers, but does not necessarily indicate the formation of an EE. Therefore, the EE and the number and nature of the parties involved in it suggest that its focus extends to what Mentzer *et al*. (2001) defined as an 'Ultimate SC'.

We may also ask whether the EE is more than an academic concept. As recently as 2005, Bititci *et al*. suggested that "although the concept of SCM has gained significant acceptance in industry, other concepts, such as EEs and Virtual Enterprises have remained as academic concepts with no real industrial and commercial application". However, the literature does provide several examples of EE's formed in various industries, such as the automobile, aerospace and locomotive one. Hence, such a statement by Bititci *et al*. (2005), alongside the previous discussion, indicates the need to further explore the field of SCM and the EE, and to develop a greater understanding of the evolutionary and definitional aspects and explore the practical issues surrounding such advanced collaborative SC formations.

CONCLUSIONS

To reflect the way organisations deal with their customers and suppliers and the types and levels of integration necessary for competitive advantage, several paradigm shifts have emerged within the development of SC theory. The paper has provided a brief outline of the evolution of SC and SCM definitions and theory, and postulated the EE concept as the current pinnacle of SCM development. We have tried to contribute to the development of understanding about the different paradigms and concepts of the SC collaborative forms, and also to clarify the differences between key SCM paradigms and concepts. In particular we have addressed some key issues relevant to the EE in the light of other concepts, sometimes confused with the EE. This review should also assist in identifying gaps in the existing knowledge, that could be used to distinguish future research questions.

REFERENCES

Bititci, U.S., Mendibil, K., Martinez, V. and Albores, P. (2005), "Measuring and Managing Performance in Extended Enterprises", *International Journal of Operations & Production Management*, Vol. 25 No.4, pp. 333-353.

Bititci, U.S., Martinez, V., Albores, P. and Parung, J. (2004). "Creating and Managing Value in Collaborative Networks", International Journal of Physical Distribution & Logistcs Management, Vol. 34 No. ¾, pp. 251-268.

Browne, J. and Zhang, J. (1999), "Extended and Virtual Enterprises - Similarities and Differences", *International Journal of Agile Management Systems*, Vol. 1 No. 1, pp. 30-36.

Burton, T.T. and Boeder, S.M. (2003), *The Lean Extended Enterprise*. Ross Publishing Inc., Florida.

Cagliano, R., Caniato, F and Spina, G. (2006), "The Linkage Between Supply Chain Integration and Manufacturing Improvement Programmes", *International Journal of Operations & Production Management*, Vol. 26 No. 3, pp. 282-299.

Chase, R.B., Jacobs, F.R. and Aquilano, N.J. (2007), *Operations Management for Competitive Advantage with Global Cases*. McGraw-Hill/Irwin, New York, 11th edition.

Christopher, M. (2005), *Logistics and Supply Chain Management: Creating Value-adding Networks*, Pearson Education Limited, Harlow, 3rd edition.

CSCMP (2010), *Council of Supply Chain Management Professionals: Supply Chain Management and Logistics Management Definitions*. (Online) Available at: http://cscmp.org/aboutcscmp/definitions/definitions.asp. [Accessed March 10, 2010]

Dangayach, G.S. and Deshmukh, S.G. (2001), "Manufacturing Strategy: Literature Review and Some Issues", *International Journal of Operations & Production Management*, Vol. 21 No. 7, pp. 884-932.

Davis, E.W. and Spekman, R.E. (2004), *The Extended Enterprise: Gaining Competitive Advantage through Collaborative Supply Chains*. Prentice Hall, New Jersey.

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

Ellram, L.M. and Cooper, M.C. (1990) "Supply Chain Management, Partnerships, and the Shipper-Third Party Relationship", *International Journal of Logistics Management*, Vol. 1 No. 2, pp. 1-10.

Graham, G. and Ahmed, P. (2000), "Buyer-Supplier Management in the Aerospace Value Chain", *Integrated Manufacturing Systems*, Vol. 11 No. 7, pp. 462-468.

Jones, T.C. and Riley, D.W. (1987), "Using Inventory for Competitive Advantage through Supply Chain Management", *International Journal of Physical Distribution & Logistics Management*, Vol. 17 No. 2, pp. 94-104.

Handfield, R.B. and Nichols, E.L. (2002), *Supply Chain Redesign: Transforming Supply Chains into Integrated Value System*. Prentice Hall, New Jersey.

Handfield, R.B. and Nichols E.L. (1999), *Introduction to Supply Chain Management*. Prentice-Hall, New Jersey.

Harland, C.M., Lamming, R.C. and Cousins, P.D. (1999), "Developing the Concept of Supply Strategy", *International Journal of Operations & Production Management*, Vol. 19 No. 7, pp. 650-673.

Harrison, A. and Van Hoek, R. (2008), *Logistics Management and Strategy: Competing through the Supply Chain*. Pearson Education Limited, Essex, 3rd edition.

Heizer, J., Render, B. (2011) *Operations Management*. Pearson Education, New Jersey, 10th edition.

Hill, T. (2000), *Manufacturing Strategy: Text with Cases.* McGraw-Hill, Boston, 3rd edition.

Houlihan, J.B. (1985), "International Supply Chain Management", *International Journal of Physical Distribution & Logistics Management*, Vol. 15 No. 1, pp. 22-38.

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 No. 1, pp. 26-33.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998), "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management*, Vol. 9 No. 2, pp. 1-20.

Larson, P.D., Poist, R.F. and Halldórsson, Á. (2007), "Perspectives on Logistics vs. SCM: A Survey of SCM Professionals", *Journal of Business Logistics*, Vol. 28 No. 1, pp. 1-24.

Lummus, R.R., Krumwiede, D.W. and Vokurka, R.J. (2001), "The Relationship of Logistics to Supply Chain Management: Developing a Common Industry Definition", *Industrial Management & Data Systems*, Vol. 101 No. 8, pp. 426-432.

Lysons, K. and Farrington, B. (2006), *Purchasing and Supply Chain Management*. Pearson Education Limited, Essex, 7th edition.

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*, Vol. 22 No. 2, pp. 1-25.

Mentzer, J.T. (2000), "Supply Chain Management". Sage Publications, California. In Mentzer (2006), *Fundamentals of Supply Chain Management: Twelve Drivers of Competitive Advantage*. Sage Publications, California.

Min, S. (2000), "Inter-corporate Cooperation in Supply Chain Management", in Mentzer, J.T. (2000) *Supply Chain Management*. Sage Publications, California.

Monczka, R.M. and Morgan, J. (1997), "What's Wrong with Supply Chain Management?", *Purchasing*, Vol. 122 No.1, pp.69-73.

Morden, T. (2007), *Principles of Strategic Management*. Ashgate Publishing Limited, Hampshire.

O'Neill, H. and Sackett, P. (1994), "The Extended Manufacturing Enterprise Paradigm", *Management Decision*, Vol. 32 No. 8, pp. 42-49.

Owen, L., Goldwasser, C., Choate, K. and Blitz, A. (2008), "Collaborative Innovation throughout the Extended Enterprise", *Strategy & Leadership*, Vol. 36 No. 1, pp. 39-45.

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

Schary, P.B. and Skjøtt-Larsen, T. (2003), *Managing the Global Supply Chain*, Copenhagen Business School Press, Copenhagen, 2nd edition.

Shapiro, J.F. (2004), "Strategic Planning: Now More Important than Ever", *Supply Chain Management Review*, Vol. 8 No. 4, pp. 13-14.

Sehdev, K., Fan, I., Cooper, S. and Williams, G. (1995), "Design for Manufacture in the Aerospace Extended Enterprise", *World Class Design to Manufacture*, Vol. 2 No. 2, pp. 28-33.

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

Slack, N., Chambers, S. and Johnston, R. (2010), *Operations Management*, Pearson Education Limited, Essex, 6th edition.

Slack, N. and Lewis, M. (2008), *Operations Strategy*, Prentice Hall – Financial Times – Pearson Education Limited, Essex, 2nd Edition.

Slack, N., Chambers, S., Harland, C., Harrison, A. and Johnston, R. (1998), *Operations Management*, Financial Times – Pitman Publishing, London, 2nd edition.

Spekman, R.E. and Davis, E.W. (2004), "Risky Business: Expanding the Discussion on Risk and the Extended Enterprise", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 5, pp. 414-433.

Spekman, R.E., Kamauff, J.W. and Myhr, N. (1998), "An Empirical Investigation into Supply Chain Management: A Perspective on Partnerships", *International Journal of Physical Distribution & Logistics Management*, Vol. 28 No. 8, pp. 630-650.

Spekman, R.E., Salmond, D. and Kamauff, J.W. (1994), "At Last Procurement Becomes Strategic", *Long-Range Planning*, Vol. 27 No. 2, pp. 76-84.

Stevenson, W.J. (2007) *Operations Management: International Student Edition with Global Readings*, McGraw-Hill/Irwin, NY, 9th edition.

Szwejczewski, M., Lemke, F. and Goffin, K. (2005), "Manufacturer-Supplier Relationships: An Empirical Study of German Manufacturing Companies", *International Journal of Operations & Production Management*, Vol. 25 No. 9, pp. 875-897.

Tonchia, S. and Tramontano, A. (2004), *Process Management for the Extended Enterprise*. Springer, Berlin.

Xu, K., Dong, Y. and Evers, P.T. (2000), "Towards Better Coordination of the Supply Chain", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 37 No. 1, pp. 35-54.

SECTION 2 – Supply Chain Inter-Firm Networks and Collaboration

WE SELECT GREEN – CASE STUDY OF THE NIKO TRANSPORT D.O.O. COMPANY

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ABSTRACT
The operational efficiency of the transport-logistics chains is affected by all actors involved: linear companies, port authorities, stevedores, forwarders, agents as well as of the level of integration of hinterland transportation modes.

At the moment, only the company Niko Transport d.o.o. offers the intermodal way of transport in Slovenia. The new strategy of the company was named »We select green«. Its main goal is the same effect with lower pollution. They understand they are part of whole logistic chains for which it is typical to become more and more sensible to the demands that concern the protection of the environment. That is also one of the priority strategies of the EU. Launched in the Freight Transport Logistics Action Plan, Green Corridors support today the EU's agenda towards decarbonising transport while emphasising the need for efficient logistics.

Niko Transport d.o.o. is a Slovenian transport company, which was established in 1990. All of their trucks, which are one to one and a half year old, meet the ECO standards and are equipped with a CVS Mobile tracking navigational device that enables the customers to track them over their web page. Because they understand transport as a part of the whole service, they developed a partner relation with their customers and also with the contractors.

The targeted market of the Niko Transport d.o.o. company is centred to the EU market. Scandinavia and Spain were already tested as well as southern markets down to Greece. Not long after they started the business they found themselves on the UK market with which they make 40% of their traffic. They are connected with their partner Anglo Overseas from Glasgow and with the introduction of the multimodal transport, with their new partner the TPC Freight Management.

The goal of the article is to present the business of the Niko Transport d.o.o. company on the UK market, the introduction of the multimodal transport, the approval of the Marco Polo project, the selection of courses and partners. A research of the students of the Caledonian University of Glasgow as a part of the project is also presented in the article.

INTRODUCTION
Globalisation is increasing the competitive struggle and enables success only to those companies in the service sector that are capable to respond to new needs and greater expectations of transport users so that they can get lower transport prices, safer transport and of course a clean manner of transport.
The most decisive fight is held on a market that is globalised to the point that we cannot speak of a local market on which we already have a certain advantage just because it is "ours". There is less and less protection while information sharing and awareness among people is increasing.

The intermodal transport feature comes from the needs of users that demand greater quality of transport services. This is represented mostly in:

- greater transport speed; this meaning not only the technical speed of the transport means but the transition speed of the whole transport process,
- uninterrupted transport; which means that the goods are transported directly from the sellers warehouse to the buyers warehouse without reloading,
- greater transport flexibility; it is a demand that transport organizations adapt quicker to their users needs with transport means regarding the sort and quantity of the goods in a chronologic and spatial sense,
- handling quality; this means that the damage and loss of goods must be as low as possible,
- moderate transport expenses; all the expenses that build up in the transport process must be proportional to the terms and quality of the transport services,

These factors caused changes in the business conduct of transport organisations which began to adapt to the markets demands. This means the formation of a complete transport service »from head to toe«. This includes the entire linking of different services in the transport process, from loading at the manufacturer to the unloading at the buyer.

THE MARCO POLO PROGRAM

The Marco Polo Program is a high-risk program that, as its predecessor PACT, supports financially a commercial activity of transport and logistics. The purpose of the program is to accelerate the development of intermodality as the main and only alternative to road transport. Research has shown that truck transport is increasing rapidly. This was greatly influenced by the new EU members for whom the truck transport market has opened without permits. Because the transport means of the new EU members were »dirtier« the pollution increased in the most developed economic countries. Every year the EU announces a call for applications for the Marco Polo program where members of the EU and other countries bordering the EU that have signed a special associating agreement can collaborate. A condition for a company from an other country is also that it has collaborated in transport within the EU region and the other country until now. The purpose of the EU financing through the Marco Polo program is that road permeability is met once more, greenhouse gas emissions are reduced and that this does not reduce the quantity of transported cargo.

In 1992 the EU set clear financial directives for the establishment of intermodal transport as an environmentally friendly form of transport. The firs program, PACT, lunched in 1992 already encouraged transport means operators to use the intermodal transport and its updates. This program was concluded in 2001 with the last project ending in 2004. With the experience gained from the PACT program, they defined the Marco Polo I program in 2001 which was more open and financially stronger then the PACT program. The first part of the Marco Polo program for which 102 million euros were made available, is expected to last form 2003 to 2010 with the last application till the end of 2006.

In July 2004 the European committee presented the European parliament with a proposal for the introduction of the second part of the Marco Polo II program for the period from 2007 to 2013. In the second part they expanded the area of usage as also the budget of the program. The second part of the Marco polo II program expanded the financing possibilities in the MOS model (*Motorways of the sea*) and the Traffic avoidance actions. The financial support that is determined by the committee on the basis of ton-kilometres (tkm) transferred from roads to short maritime transports, railway and land waterways or combined methods of transport where road transports are shortest, is initially determined at 1 euro for every 500 tkm of road freight transported. This indicative amount can be adapted especially in relation to the quality of the project or actual benefits gained for the environment.

PROJECT MARCO POLO IN THE NIKO TRANSPROT D.O.O. COMPANY

Because of increasing external costs, fuel costs, tolls and incentives, the Niko Transport d.o.o. company decided to make a step forward, a step that would decrease costs and also contribute to a less polluted environment. With the SLO-UK_Combi (Slovenija-United Kingdom combined transport) Consortium project, established in the Niko Transport d.o.o. company, the multimodal transport started to develop. The transport of goods from the existing road transport with loaders from Southern Europe and unloaders in the UK and Ireland, has transferred to multimodal transport. A direct intermodal service is introduced, including a railway line between Slovenia/Moste (Ljubljana) and Belgium/Zeebrugge. Also included in the project there is a short ship course between Zeebrugge and Killingholme (UK) and then delivery by road (Fig. 1). The collected goods in the UK are again taken to Killingholme port and destined mostly for Balkan countries, Italy and Austria (Fig. 2).

Figure 1: UK delivery map

(Source: Niko Transport d.o.o.)

Figure 2: Map of Italian, Slovenian and former Yugoslavian loaders and unloaders

(Source: Niko Transport d.o.o.)

The new service is used with existent customers who until now used the existent road transport namely for goods like: furniture wood components (50 %), metal products (15 %), plastic and paper products (15 %), consumer goods (10 %) and other (10 %). The goods are loaded on swap bodies which are used only for the intermodal system. This way the greater part of the goods is removed from the problematic roads and moved to railway lines (579.884.639 tkm).

Figure 3 : Swap body
(Source: Niko Transport d.o.o.)

This demanded change and purchase of the following transport needs:

a) 42 vehicles Iveco Stralis and 35 vehicles for crate towing (35 standard vehicles Iveco Stralis were changed with vehicles for crate towing),
b) 55 trailers Krone (dimensions: 13,6 x 2,80 x 2,48 m), of which the number has also decreased from around 80 to 55,
c) 200 crates (swap body) Krone TYP C-63, VOL: 90 m^3, dimensions: 13,6 x 2,75 x 2,46 m.

Example of the old road route and the new intermodal route

The old route distance (Tb. 1) from the loading point to the unloading point includes the road connection between Moste and Calais (the route goes over Slovenia, Austria, Germany, Luxemburg, Belgium and France), then the trucks go on a ferryboat in Calais for Dover. The distance between Moste and Calais is 1.481,4 km. Altogether the old route (here without the loading point and distribution) measures 1.515,3 km.

Tables 1: Combined transport / distance + route

Old road route	Mode	Distance (km)
Moste - German Border		403,2 km
German Border through Munich - Stuttgart to Luxembourg		626,8 km
Luxembourg Border to Belgium Border	Road *(Transit time: 43,5 hours)*	53,4 km
Belgium Border through Bruxelles to France Border		340,9 km
France Border to Calais		56,7 km
Calais - Dover (Ferry)		34 km
Sub-total		1515 km

Source: Program Marco Polo

The intermodal transport (Tb. 2) uses trucks for the loading of goods and the delivery of goods door-to-door. For the rest of the distance between Ljubljana and Zeebrugge the train and ferryboat are used from Zeebrugge to Killingholme. The entire distance over railway in the EU territory is 1468 km (the loading and unloading of swap bodies in Moste and in the Zeebrugge terminal).

The new ferryboat crossing between Zeebrugge and Killingholm is 372 km long.

Tables 2: The new route between Moste and Killingholm

New route	Mode	Distance (km) (Terminal/ DESTINATION)
Moste (Ljubljana) - Jesenice	Rail - (dedicated freight service) Transit time: 32 hours Ship - (dedicated freight service) Transit time: 11,5 hours	71,30 km
Jesenice – Rosenbach		30,88 km
Rosenbach - Salzburg		189,73 km
Salzburg – München		214,76 km
München - Aachen West		679,17 km
Aachen West - Montzen		14,84 km
Montzen - Zeebrugge		267,31 km
Zeebrugge - Killingholme		372 km
Sub-total		1840 km

Source: Program Marco Polo

Second example of the old road route and the new intermodal route

The second example presents the old (Fig.4) and the new route (Fig.5) which include the loading in Salgareda (Italy) and the delivery in Birmingham (UK).

Example of the old route: the loading of goods in Salgareda (Italy) and the delivery of goods in Birmingham (UK):

- Salgareda - Moste (214 km),
- Moste (Ljubljana) - Scwarzbach/B1 (323 km),
- Scwarzbach/B1 - Kircheim Unter Teck (349 km),
- Kircheim Unter Teck - Luxemburg (390 km),
- Luxemburg - Calais (419 km),
- Calais - Dover (34 km),
- Dover - Birmingham (331 km).

Altogether the route amounts to 2060 km.

The picture below represents the old route way which is calculated taking into account the data of the Salgareda – Birmingham route length.

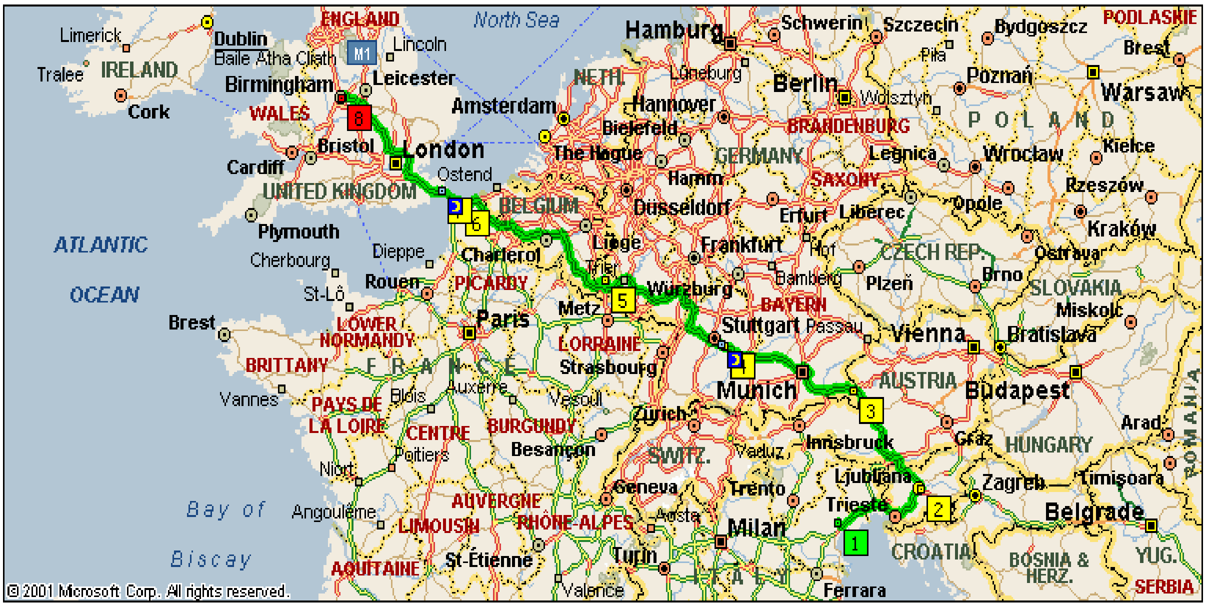

Figure 4: Salgareda – Birmingham route map

(Source: Niko Transport d.o.o.)

For the new route (intermodal transport) an example is used where the goods are loaded in Salgareda (Italy) and delivered in Birmingham (UK):

- Salgareda - Moste (214 km by roadi),
- Moste (Ljubljana) - Zeebrugge (1468 km by railway),
- Zeebrugge - Killingholme (ferryboat, 372 km),
- Killingholme - Birmingham (218 km by road).

Altogether the route amounts to 2272 km.

The picture below represents the new transport way which is calculated taking into account the data of the Salgareda – Birmingham rout length.

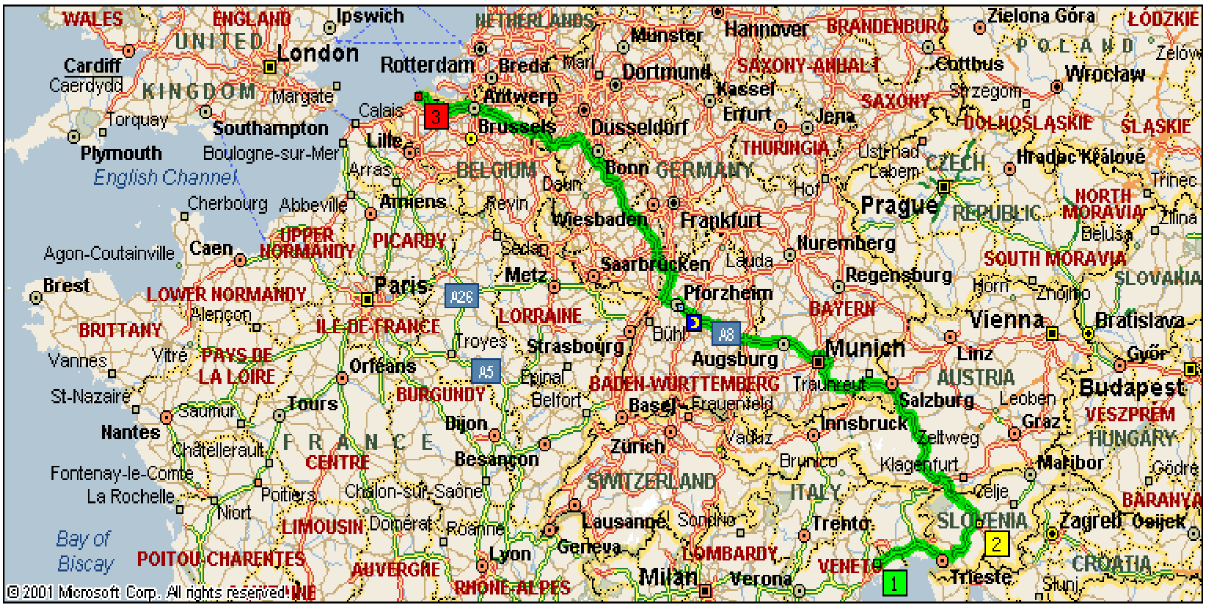

Figure 5: Salgareda – Zeebrugge route map

(Source: Niko Transport d.o.o.)

A RESEARCH OF THE STUDENTS OF THE CALEDONIAN UNIVERSITY OF GLASGOW

The research of the students related to figuring out the potential quantity of goods for transport or how to increase the existent quantities of goods. Connected to that, a market segmentation and gathering of data for the entire UK market, individual and local regions are done. Many useful data is gathered about transport companies in the UK and about industrial areas in the central region of the UK. It showed for many companies that they export to Slovenia and countries near Slovenia and that they are strongly connected to the Killingholme port. The students have suggested in the research that the company Niko Transport d.o.o. starts advertising its services directly by e-mail or by advertising agencies and newspapers. For the public and the companies in the UK today it is typical to press more and more on the transport companies to use greener ways of transport.

CONCLUSION

The expenses and care for the environment are becoming one of the key elements for road transport. That is why the company Niko Transport d.o.o. decided for the multimodal (road-train-ship) way of transport. This decision can potentially offer the company good long-term results.

The problem with which Niko Transport d.o.o. is currently facing is in the insufficient quantity of goods referring especially to the export from the UK into Slovenia, Croatia and Italy. The students of Caledonian University from Glasgow are assessing in this context in the research that additional quantities of goods exist and suggest that it would be necessary to connect long-term with manufacturing companies, increase orders of existent forwarding agents and find new forwarding agents.

REFERENCES

1. Mulder F. "Advanced Technologies in Green Transport Corridors" EU Green Corridors Conference, Brussels - 9th December 2009

2. Marco Polo Programme - Call 2007;SLO-UK_COMBI Consortium

3. http://ec.europa.eu/transport/marcopolo

4. www.niko-transport.si

STABILITY OF LOGISTICS NETWORKS WITH VARYING CAPACITY OF NODES SUBJECT TO TIME DELAYS

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ABSTRACT
Logistics network represents a complex system where different elements that are logistic locations interact with each other. This interaction is subject to time delays caused by time needed for delivery of the material. In this paper we study local input-to-state stability of such logistics networks. Their behaviour is described by a functional differential equation with a constant time-delay. An appropriate Lyapunov-Razumikhin function and the small gain condition are utilized to establish some conditions for stability analysis of the network under consideration. Our stability conditions for the logistics network are based on the information about the interconnection properties between logistic locations and their production rates. Finally, numerical results are provided to demonstrate an application of the proposed approach.

Purpose:
Design of stable logistics networks with time-delays

INTRODUCTION
Modelling of logistics networks is of high interest for many logistic companies, requiring new techniques and methods for their operation and management applications. Mathematical models provide an opportunity to simulate a logistics system to investigate its properties like performance, stability, robustness and to design appropriate controls to improve these properties, see [3], [11] and [17]. Such networks are large scale interconnected systems with a nonlinear behaviour, moreover they are subject to internal and external perturbations that can destabilize the network and lead to a decrease in performance or a break down. Due to the complexity, such systems are hard to analyze and to control. A decentralized control is in many cases the only one possibility to keep its running. Such basic properties as stability and robustness against disturbances must be assured for a reasonable behaviour of the system. Since reactions on changes happening in the system and the disturbances are often delayed in time, we will use differential equations with time delays in our approach.

On the other hand, delay-differential equations occur in many areas like engineering systems, robotics, economics or biological systems. For instance, in economic systems, delays appear in a natural way since decisions and effects are separated by some time interval. The delay effects on the stability of systems is a problem of recurring interest since the delay presence may induce complex and undesired behaviours (oscillation, instability, bad performance) for the schemes, see [4], [6], [9], [10], [15], [16] and [18]. In the present paper we study stability of logistic networks modelled as a system of delay-differential equations as well. By dynamics of the network we consider the change at the stock level of logistic location. This change is caused by the own production and by the flow of material from other locations. As the locations are situated usually far from each other the flow arrives with a time delay.

Roughly speaking, we call a logistic network stable if the stock level of each its location remains bounded for all times. It is also robust against disturbances (seen as external inputs) if this level depends only on the magnitude of the disturbance. This is the desired property that we are going to assure in the logistics networks. To this end we will work in the framework of input-to-state stability (ISS) that was introduced first for the systems without delays by Sontag in [12]. ISS for time-delay systems was first considered by Teel in [13]. In the same paper, Teel introduces ISS of time-delay systems in terms of Lyapunov functions that are called ISS Lyapunov-Razumikhin functionals. A Lyapunov-Razumikhin technique was also considered in [5]. However, ISS analysis of the logistics networks that includes time-delays in their states (stock levels) is an important problem, so far a very little attention has been paid for the investigation of this problem, see [3]. This motivates the present study.

In this paper, we consider the local versions of ISS as in real logistics networks all initial conditions and inputs can be taken uniformly bounded. For the systems without delays there are known small gain conditions that guarantee stability of the interconnected system if each subsystem of a network is ISS, see [7], [1], [2] and [8]. These conditions are also applied for time-delays systems as well, see [14] and [8], and will be used here for stability analysis of logistics networks. We will consider a typical logistic network and derive explicit conditions for its stability. These conditions will be given in terms of restrictions of maximal production rates of the locations in the network. Finally, simulation results are given to illustrate the usefulness of the proposed approach.
The structure of the paper is as follows. In Section 2 the notion of ISS for time-delayed systems is presented. The small gain theorems needed for stability analysis are also given. In Section 3 we apply the small gain condition for stability analysis in a typical logistics network that is modelled as a time-delay dynamical system and provide an illustrative example there. Finally, conclusions are presented in Section 4.

STABILITY OF TIME-DELAY SYSTEMS

Let IR_+ be the set of nonnegative real numbers, IR_+^n be the positive orthant $\{x \in IR^n : x \geq 0\}$ and $IN_+ := \{0,1,2,\ldots\}$. x^T stands for the transposition of a vector $x \in IR^n$. For $x, y \in IR^n$, we use the partial order induced by the positive orthant. It is given by

$$x \geq y \Leftrightarrow x_i \geq y_i,\, i = 1,\ldots,n,$$
$$x > y \Leftrightarrow x_i > y_i,\, i = 1,\ldots,n.$$

We write $x \not\geq y \Leftrightarrow \exists i \in \{1,\ldots,n\} : x_i < y_i$.
For a function $v : IR_+ \to IR^m$ we define its restriction to the interval $[s_1, s_2]$ by

$$v_{[s_1,s_2]}(t) = \begin{cases} v(t), if\ t \in [s_1, s_2], \\ 0, \quad otherwise. \end{cases}$$

Consider a system that is an interconnection of a set of subsystems with state $x := (x_1^T,\ldots,x_n^T)^T$, given by the states $x_i \in IR^{N_i}, i = 1,\ldots,n$ of the subsystems and denote $N = \sum_{i=1}^{n} N_i$. Dynamics of the ith subsystem Σ_i is given by the *functional differential equations*:

$$\dot{x}_i(t) = f_i\big(t, x_1(t),\ldots,x_n(t), x_{d1}(t),\ldots,x_{dn}(t), u_i(t)\big),\ \ x_i(t) = \xi_i(t) \text{ for } t \in [-T,0) \qquad (1)$$

where $u_i : [-T,+\infty] \to IR_+^m$ is a bounded piecewise continuous external input for ith subsystem and $x_j, x_{dj}, j \neq i$ are internal inputs from subsystems $j, j \neq i$ where $x_{dj}(t) := x_j(t-T)$ is given with a delay $T > 0$. Functions $f_i : IR^{1+2N+M} \to IR_i^N$ and initial data $\xi_i : IR \to IR_+^{N_i}$ are continuous.
We define $|\cdot|$ some norm in IR^n, essential supremum norm of a measurable function u_i by $\| u_i \|_\infty$, $|x_{di}| := \max_{t-T \leq s \leq t} |x_i(s)|$ and $\| x_{di} \|_{t_0} := \sup_{s \geq t_0} |x_{di}(s)|$.
A function $\alpha : IR_+ \to IR_+$ with $\alpha(0) = 0$ and $\alpha(t) > 0$ for $t > 0$ is called positive definite. A function $\gamma : IR_+ \to IR_+$ is said to be of class K if it is continuous, strictly increasing and

$\gamma(0)=0$. It is of class K_∞ if, in addition, it is unbounded. Note that for $\gamma \in K_\infty$ the inverse function γ^{-1} always exists and $\gamma^{-1} \in K_\infty$. A function $\beta : IR_+ \times IR_+ \to IR_+$ is said to be of class KL if, for each fixed t, the function $\beta(\cdot,t)$ is of class K and, for each fixed s, the function $\beta(s,\cdot)$ is non-increasing and tends to zero for $t \to \infty$. Function $id : IR \to IR$ is such that $id(s)=s$ for all $s \in IR$ and for any functions f and g we denote $f \circ g := f(g)$.
The interconnection Σ of subsystems (1) is given by

$$\dot{x} = f(t,x,x_d,u) = \begin{pmatrix} f_1(t,x_1,...,x_n,x_{d1},...,x_{dn},u_1) \\ \vdots \\ f_n(t,x_1,...,x_n,x_{d1},...,x_{dn},u_n) \end{pmatrix} \tag{2}$$

We study local input-to-state stability of systems (1) and (2).

Definition 2.1: The ith subsystem in (2) is called *locally input-to-state stable (LISS)* if there exist $\beta \in KL, \gamma \in K_\infty \cup \{0\}, r>0$, such that for any initial data $\xi, \|\xi\|_\infty < r$, any measurable, locally essentially bounded input u, the solution exists for all $t \ge 0$ and furthermore it satisfies

$$|x(t)| \le \max\{\beta(\|\xi\|_\infty, t),\ \gamma(\|u_{[0,t)}\|_\infty)\} \tag{3}$$

Function γ is called a nonlinear gain.

Definition 2.2: The ith subsystem is *LISS* if there exist $\beta_i \in KL, \gamma_{ij}, \gamma_i \in K_\infty \cup \{0\}, r_i > 0$, such that for any $\xi_i, \|\xi_i\|_\infty < r_i$, any essentially bounded inputs x_j, x_{dj}, u_i the solution exists for all $t \ge 0$ and satisfies

$$|x_i(t) \le \max\{\beta_i(\|\xi_i\|_\infty, t),\ \max_{j,j\ne i}(\|x_{dj[0,t]}\|_\infty),\ \gamma_i(\|u_{i[o,t)}\|_\infty)\} \tag{4}$$

For stability analysis of system (2) we use the following Razumikhin-type theorem that is an extension of the result in [13] to the case of local input-to-state stability.

Theorem 2.3: If there exist $\alpha_1, \alpha_2 \in K_\infty$, a continuous function $V:[-T,\infty)\times IR^N \to IR_{\ge 0}$, $\gamma_v, \gamma_u \in K$ and $\alpha_3 \in K, \rho, \rho_u > 0$ such that
1) $\alpha_1(|x(t)|) \le V(t) \le \alpha_2(|x(t)|)$;
2) $V(t) \ge \max\{\gamma_v(|V_d(t)|), \gamma_u(|u(t)|)\} \Rightarrow D^+V(t) \le -\alpha_3(|x(t)|), \|x_{[-T,0)}\|_\infty < \rho, \|u\|_\infty < \rho_u$ where $D^+V(t) := \limsup_{h\to 0^+} \frac{V(t+h)-V(t)}{h}$;
3) $\gamma_v(s) < s$ for $s>0$; then the origin is LISS.
Function V is called *local input-to-state stable (LISS) Lyapunov-Razumikhin function*.

Remark 1: This result can be also stated for the case of systems with many inputs. See the following theorem.

Theorem 2.4: If there exist $\alpha_{i1}, \alpha_{i2} \in K_\infty$, a continuous function $V_i:[-T,\infty)\times IR^{N_i} \to IR_{\ge 0}$, $\gamma_{iv}, \gamma_{iu}, \gamma_{ij} \in K$ and $\alpha_{i3} \in K, \rho_i, \rho_{iu} > 0$ such that
1) $\alpha_{i1}(|x_i(t)|) \le V_i(t) \le \alpha_{i2}(|x_i(t)|)$;
2) $V_i(t) \ge \max\{\gamma_{iv}(|V_{id}(t)|), \max_j \gamma_{ij}(|x_{jd}(t)|), \gamma_{iu}(|u_i(t)|)\} \Rightarrow D^+V_i(t) \le -\alpha_{i3}(|x_i(t)|),\ \|x_{i[-T,0)}\|_\infty < \rho_i$, $\|u_i\|_\infty < \rho_{iu}$;
3) $\gamma_{iv}(s) < s$ for $s>0$;
then the origin is LISS.

Note that the existence of the LISS Lyapunov-Razumikhin function for all subsystems Σ_i does not guarantee that the whole interconnected system Σ will be LISS. To guarantee

LISS of system Σ we use the following operator, introduced in [1] and [2]. This operator is defined in terms of the gains γ_{ij} and in particular it depends on the interconnection structure of the system.

Consider operator $\Gamma: IR_+^n \to IR_+^n$ defined by

$$\Gamma(s) := \begin{pmatrix} \max\limits_{j, j\neq 1} \gamma_{1j}(s_j) \\ \vdots \\ \max\limits_{j, j\neq n} \gamma_{nj}(s_j) \end{pmatrix}, \; s \in IR_+^n.$$

The next theorem provides a small-gain condition for LISS of interconnection (2) that is an extention of the results in [2] for time-delay systems.

Theorem 2.5: [Small gain condition] Assume each subsystem Σ_i has an LISS Lyapunov-Razumikhin function. If there

$$\Gamma(s) \ngeq s, \forall s, s \neq 0 \tag{5}$$

holds, then the system Σ has a LISS Lyapunov-Razumikhin function and thus is LISS. Let us apply this theorem for stability analysis of a logistics network given in the following section.

APPLICATION TO LOGISTIC NETWORKS

Consider a logistics network of 5 production locations shown in Figure 1. Delayed differential equations that describe the dynamics of each location are given in by

$$\begin{aligned} \dot{x}_1(t) &= b_1 f_1(x_1(t-T)) + c_{12} f_2(x_2(t-T)) + c_{13} f_3(x_3(t-T)) + c_{14} f_4(x_4(t-T) + \\ &\quad c_{15} f_5(x_5(t-T)) - f_1(x_1(t)) =: \tilde{f}_1(x_1,...,x_5, x_{1d},..., x_{5d}, u_1) \\ \dot{x}_i(t) &= u_i(t) + b_i f_i(x_i(t-T)) + c_{i1} f_1(x_1(t-T)) - f_i(x_i(t)) =: \tilde{f}_i(x_1,..., x_{5d}, u_5), \qquad i = 2,...,5. \end{aligned} \tag{6}$$

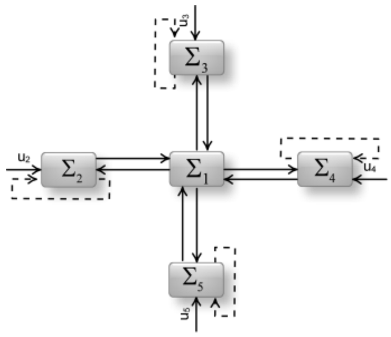

Figure 1: The logistics network.

The logistics network operates as follows. A location Σ_i gets material with a delay T from another location, produces a new product with a rate f_i and then delivers it to other locations. The state x_i in (6) is a stock level of a product i of a logistics location Σ_i, u_i is an external input coming from suppliers and c_{ij} is the part of material produced by location Σ_i delivered to location Σ_j. The component $b_i f_i(x_i(t-T))$ determines amount of the returned material after time period T because of wastes or rejections. The initial values of stock levels x_i are given by $x_i(t) = \xi_i(t), \; t \in [-T, 0)$.

A production rate of a location Σ_i is given by the function $f_i(x_i(t)) := a_i(1 - e^{-x_i(t)})$, where a_i is its maximal production rate. If the stock level x_i is high then the production rate tends to zero. If the stock level is low then the production rate f_i tends to a_i. In such a way we intend to keep the stock level low and to save capacities. Thus we can rewrite system (6) as follows

$$\dot{x}_1(t) = b_1 a_1\left(1-e^{-x_1(t-T)}\right) + c_{12}a_2\left(1-e^{-x_2(t-T)}\right) + c_{13}a_3\left(1-e^{-x_3(t-T)}\right) + c_{14}a_4\left(1-e^{-x_4(t-T)}\right) + c_{15}a_5\left(1-e^{-x_5(t-T)}\right) - a_1\left(1-e^{-x_1(t)}\right)$$
$$\dot{x}_i(t) = u_i(t) + b_i a_i\left(1-e^{-x_i(t-T)}\right) + c_{i1}a_1\left(1-e^{-x_1(t-T)}\right) - a_i\left(1-e^{-x_i(t)}\right), \qquad i = 2,...,5.$$

It is easy to check that if $\xi_i(t) \geq 0, t = [-T,0)$, then $x_i(t) \geq 0$ for all $t \geq 0, i = 1,...,5$. To apply Theorem 2.5 for stability analysis of the supply chain we need to find LISS Lyapunov-Razumikhin function for each subsystem.

Let $V_i(x_i(t)) = x_i(t), i = 1,...,5$, where $x_i(t) \geq 0$. The condition 1) in Theorem 4 is easily satisfied. Let us check the condition 2). Consider $V_1(x_1(t)) = x_1(t)$ and

$$\gamma_{1j}(x_j) := -\ln\left(1 - \frac{\sum_{k=2}^{5} c_{1k}a_k + b_1 a_1}{(1-\varepsilon_{1j})a_1}\left(1-e^{-x_j}\right)\right),\ j = 2,...,5, \varepsilon_{1j} \in (0,1) \tag{7}$$

$$\gamma_{1v}(x_1) := -\ln\left(1 - \frac{\sum_{k=2}^{5} c_{1k}a_k + b_1 a_1}{(1-\varepsilon_{1v})a_1}\left(1-e^{-x_1}\right)\right),\ \varepsilon_{1v} \in (0,1). \tag{8}$$

Functions $\gamma_{1j}, \gamma_{1v} \in K_\infty$, $j = 2,...,5$ if

$$\sum_{k=2}^{5} c_{k1}a_k + b_1 a_1 < (1-\varepsilon_{1j})a_1 < a_1, \tag{9}$$

$$\sum_{k=2}^{5} c_{k1}a_k + b_1 a_1 < a_1. \tag{10}$$

Let $V_1(x_1(t)) = x_1(t) > \max\{\gamma_{12}(x_2(t-T)),....,\gamma_{15}(x_5(t-T)),\gamma_{1v}(x_1(t-T))\} \Rightarrow$

$$D^+V_1(x_1(t)) = \tilde{f}_1(x,u_1) \leq \left(\frac{b_{1v}a_1}{\sum_{k=2}^{5} c_{1k}a_k + b_1 a_1}(1-\varepsilon_{1v}) + \frac{c_{1j}a_j}{\sum_{k=2}^{5} c_{1k}a_k + b_1 a_1}(1-\varepsilon_{12}) + ... + \frac{c_{15}a_5}{\sum_{k=2}^{5} c_{1k}a_k + b_1 a_1}(1-\varepsilon_{15}) - 1\right)a_1\left(1-e^{-x_1(t)}\right) < -\varepsilon_1 a_1\left(1-e^{-x_1(t)}\right) = -\alpha_{31}\left(|x_1(t)|\right)$$

where $\varepsilon_1 := \min_{j=2,...,5,v}\{\varepsilon_{1j}\}$ and $\alpha_{31}(|x_1(t)|) := \varepsilon_1 a_1\left(1-e^{-x_1(t)}\right)$. Hence the condition 2) of Theorem 2.4 holds. Inequality (9) guaranties also that the condition 3) is satisfied. Then the function V_1 is a local Lyapunov-Razumikhin function for system Σ_1.

To show that V_j, $j = 2,...,5$ are a local Lyapunov-Razumikhin functions for system Σ_j we need

$$\gamma_{j1}(x_1) := -\ln\left(1 - \frac{\|u_j\|_\infty + b_j a_j + c_{j1}a_1}{(1-\varepsilon_{j1})a_j}\left(1-e^{-x_1}\right)\right),\ \varepsilon_{j1} \in (0,1), \tag{11}$$

$$\gamma_{jv}(x_j) := -\ln\left(1 - \frac{\|u_j\|_\infty + b_j a_j + c_{j1}a_1}{(1-\varepsilon_{jv})a_j}\left(1-e^{-x_j}\right)\right),\ \varepsilon_{jv} \in (0,1),\ j = 2,...,5. \tag{12}$$

And for $\gamma_{j1}, \gamma_{jv} \in K_\infty$ we need

$$\|u_j\|_\infty + b_j a_j + c_{j1}a_1 < a_j,\ j = 2,...,5. \tag{13}$$

$$\gamma_{ju}\left(u_j(t)\right) := -\ln\left(1 - \frac{u_j(t)(\|u_j\|_\infty + b_j a_j + c_{j1}a_1)}{\|u_j\|_\infty (1-\varepsilon_{ju})a_j}\right) \in K,\ j = 2,...,5. \tag{14}$$

Let $V_2\left(x_2(t)\right) = x_2(t) > \max\{\gamma_{21}(x_1(t-T)),\gamma_{2v}(x_2(t-T)),\gamma_{2u}(u(t))\} \Rightarrow$

$$D^+V_2(x_2(t)) = x_2(t) < \left(\frac{c_{21}a_1}{\| u_2 \|_\infty + b_2 + c_{21}a_1}(1-\varepsilon_{21}) + \frac{b_2 a_2}{\| u_2 \|_\infty + b_2 a_2 + c_{21}a_1}(1-\varepsilon_{2v}) \right.$$
$$\left. + \frac{\| u_2 \|_\infty}{\| u_2 \|_\infty + b_2 a_2 + c_{21}a_1}(1-\varepsilon_{2u}) - 1 \right) a_2\left(1-e^{-x_2(t)}\right) < -\varepsilon_2 a_2\left(1-e^{-x_2(t)}\right) = -\alpha_{32}\left(| x_2(t) |\right)$$

where $\varepsilon_2 := \min\{\varepsilon_{21}, \varepsilon_{2v}, \varepsilon_{2u}\}$ and $\alpha_{32}(| x_2(t) |) := \varepsilon_2 a_2\left(1-e^{-x_2(t)}\right)$. Hence the condition 2) of Theorem 2.4 holds. To satisfy the condition 3) we need (13). Then it follows that V_2 is a local Lyapunov-Razumikhin function for system Σ_2. In a similar way we can check that functions $V_3,\ldots,V_5$ are local Lyapunov-Razumikhin functions for systems Σ_3, Σ_4 and Σ_5 accordingly.

Let us check the small gain condition (5). From [1] the inequality $\Gamma \not\geq id$ is equivalent to:

$$\gamma_{1j} \circ \gamma_{j1} < id,\ j = 2,\ldots,5. \tag{15}$$

Consider the left-hand side of the inequality (15)

$$\gamma_{1j} \circ \gamma_{j1}(s) = -\ln\left(1 - \frac{\sum_{k=2}^{5} c_{k1}a_k + b_1 a_1}{(1-\varepsilon_{1j})a_1} \frac{\| u_j \|_\infty + b_j a_j + c_{j1}a_1}{(1-\varepsilon_{j1})a_j}(1-e^{-s})\right) < s, \forall s > 0.$$

if

$$\frac{\sum_{k=2}^{5} c_{k1}a_k + b_1 a_1}{(1-\varepsilon_{1j})a_1} \frac{\| u_j \|_\infty + b_j a_j + c_{j1}a_1}{(1-\varepsilon_{j1})a_j} < 1. \tag{16}$$

From (9) and (13) there exist such $\varepsilon_{1j}, \varepsilon_{j1} \in (0,1)$ that the inequality (19) holds. Thus the condition (15) holds and by Theorem 2.5 the whole system is LISS.

The following examples are numerical simulations compared with theoretical results.

Example 3.1 Let us take values $c_{12} = 0.3, c_{13} = 0.1, c_{14} = 0.3, c_{15} = 0.5, c_{21} = 0.3, c_{31} = 0.1, c_{41} = 0.2,$ $c_{51} = 0.3$ for the shares of delivered products, $b_1 = 0.05, b_2 = 0.06, b_3 = 0.05, b_4 = 0.1, b_5 = 0.03,$ for the rate of returned products and $u_2 = 3, u_3 = 1, u_4 = 2, u_5 = 5,$ for external inputs.

The time delay is $T = 0.2$. The initial values of stock level are given by $x_i(t) = 1,\ i = 1,\ldots,5,$ $t \in [-0.2, 0)$. To have the gains well-defined we need to satisfy conditions on maximal production rates (9) and (13)

$$c_{12}a_2 + c_{13}a_3 + c_{14}a_4 + c_{15}a_5 + b_1 a_1 < a_1,$$
$$\| u_j \|_\infty + b_j a_j + c_{j1}a_1 < a_j,\ j = 2,\ldots,5.$$

Taking maximal production rates $a_1 = 8, a_2 = 5.8, a_3 = 3, a_4 = 5.2$ and $a_5 = 7.8$ we can check these conditions

$$c_{12}a_2 + c_{13}a_3 + c_{14}a_4 + c_{15}a_5 + b_1 a_1 = 0.3\cdot 5.8 + 0.1\cdot 3 + 0.3\cdot 5.2 + 0.5\cdot 7.8 + 0.05\cdot 8 = 7.9 < 8,$$

$$\| u_2 \|_\infty + b_2 a_2 + c_{21}a_1 = 3 + 0.06\cdot 5.8 + 0.3\cdot 8 = 5.748 < 5.8, \rho_{2u} = 3.052,$$
$$\| u_3 \|_\infty + b_3 a_3 + c_{31}a_1 = 1 + 0.05\cdot 3 + 0.1\cdot 8 = 1.95 < 3, \rho_{3u} = 2.05,$$
$$\| u_4 \|_\infty + b_4 a_4 + c_{41}a_1 = 2 + 0.1\cdot 5.2 + 0.2\cdot 8 = 4.12 < 5.2, \rho_{4u} = 3.08,$$
$$\| u_5 \|_\infty + b_5 a_5 + c_{51}a_1 = 5 + 0.03\cdot 7.8 + 0.3\cdot 8 = 7.634 < 7.8, \rho_{5u} = 5.166.$$

The simulation results are given in Figure 2. As one can mention all the stock levels are bounded. If one of the inequalities in conditions (9) and (13) is not satisfied we cannot guarantee stability of the network that is shown in the next example.

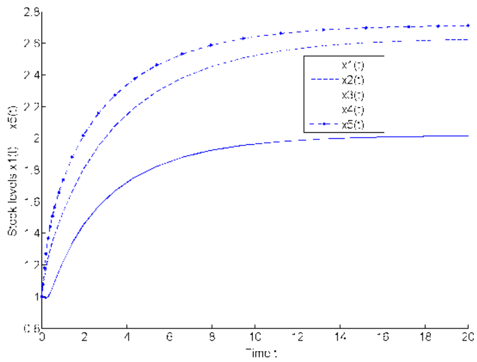

Figure 2: The stock levels at locations.

Example 3.2
Consider the same network as in the previous example. The only difference is in the maximal production rate of logistic location Σ_5 that is now $a_5 = 7$. The last condition on the production rates is not satisfied

$$\| u_5 \|_\infty + b_5 a_5 + c_{51} a_1 = 5 + 0.03 \cdot 7 + 0.3 \cdot 8 = 7.61 > 7.$$

Simulation results given in Figure 3 show that the stock level of the fifth location is unbounded.

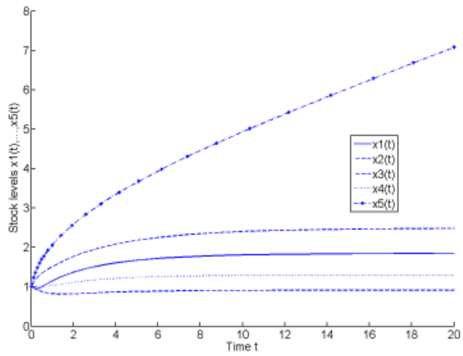

Figure 3: The stock levels at locations.

CONCLUSIONS
The problem of stability analysis for a class of logistics networks with time delays was investigated in this paper. We have provided a generic approach for modelling of these networks with different production rates of each location and constant time delays in the deliveries. The system under consideration is an interconnection of subsystems that are logistic locations. An appropriate Lyapunov-Razumikhin functional and the small gain condition were utilized to establish some delay-independent conditions on the interconnection and production rates that guarantee local input-to-state stability of the network. Finally, numerical results were provided to demonstrate an application of these conditions. Our approach is generic and can be used for larger systems with arbitrary topology. This approach can be used for design of logistics networks or supply chains. Future work will investigate delay-dependent stability analysis for the network under consideration by considering an appropriate Lyapunov-Razumikhin functional which insert the delay terms into the functional.

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REFERENCES

[1] Dashkovskiy, S., Rüffer, B. and Wirth, F. (2007), "An ISS small-gain theorem for general networks",*Math. Control Signals Systems*, 19, pp. 93–122.
[2] Dashkovskiy, S. N., Rüffer, B. S. and Wirth, F. R., "Small gain theorems for large scale systems and construction of ISS Lyapunov functions", *Accepted for publication in SIAM Journal on Control and Optimization*, http://arxiv.org/pdf/0901.1842.
[3] S. Dashkovskiy, M. Görges, L. Naujok (2009), "Local input to state stability of production networks", *Proc. of the Second International Conference on Dynamics in Logistics, LDIC 2009, Bremen, Germany, August 2009*.
[4] Esfanjani, R.M., Reble, M., Münz, U., Kamaleddin, S., Nikravesh, Y. and Allgöwer, F. (2009), "Model predictive control of constrained nonlinear time-delay systems", *Proc. of CDC/CCC 2009, The Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference, Shanghai, P.R. China, December 16-18, 2009*.
[5] Hou, C. and Qian, J. (1998), "On an estimate of the decay rate for applications of Razumikhin-type theorems", *IEEE Transactions on Automatic Control*, 43, 958–960.
[6] Ignaciuk, P. and Bartoszewicz, A. (2009), "LQ optimal inventory control for multi-supplier periodic-review systems with disparate lead-time delay", *Proc. of CDC/CCC 2009, The Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference, Shanghai, P.R. China, December 16-18, 2009*.
[7] Jiang, Z.-P., Mareels, I. M. Y. and Wang, Y. (1996), "A Lyapunov formulation of the nonlinear small-gain theorem for interconnected ISS systems", *Automatica J. IFAC*, 32, pp. 1211–1215.
[8] Karafyllis, I. and Jiang, Z.-P. (2009), "A vector small-gain theorem for general nonlinear control systems", *submitted*, http://arxiv.org/pdf/0904.0755.
[9] Niculescu, S.-I. and Gu, K. (2004), "Advances in time-delay systems", *Springer*.
[10] Shi, P. (1998), "Robust control of linear continuous time-delay systems with finite discrete jumps and norm-bounded uncertainties", *International Journal of Systems Science*, 29, pp. 1381–1392.
[11] Silva C.A., Sousa, J.M.C., Runkler, T.A., Sa da Costa, J.M.G. (2006), "Distributed optimisation of a logistic system and its suppliers using ant colonies", *International Journal of Systems Science*, 37, pp. 503–512.
[12] Sontag, E.D. (1989), "Smooth stabilization implies coprime factorization", *IEEE Trans. Automat. Control*, 34, pp. 435–443.
[13] Teel, A. R. (1998), "Connections between Razumikhin-type theorems and the ISS nonlinear small gain theorem, *IEEE Trans. Automat. Control*, 43, pp. 960–964.
[14] Tiwari, S., Wang, Y. and Jiang, Z.-P. (2009), "A nonlinear small-gain theorem for large-scale time delay systems", *Proc. of CDC/CCC 2009, The Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference, Shanghai, P.R. China, December 16-18, 2009*.
[15] Wang, Q., Lam, J., Xu, S. and Gao, H. (2005), "Delay-dependent and delay-independent energy-to-peak model approximation for systems with time-varying delay", *International Journal of Systems Science*, 36, pp. 445–460.
[16] Wang, Z. and Gao, H. (2009), "Analysis and synchronization of complex networks", *International Journal of Systems Science*, 40, pp. 905–907.
[17] Wu Y. (2008), "A mixed-integer programming model for global logistics transportation problems", *International Journal of Systems Science*, 39, pp. 217–228.
[18] Xia, Y., Liu, G. P., Shi, P., Rees, D. and Thomas, E.J.C. (2007), "New stability and stabilization conditions for systems with time-delay", *International Journal of Systems Science* 38, pp. 17–24.

CURRENT ISSUES AND CHALLENGES OF CONTAINER SECURITY DEVICES IMPLEMENTATION IN SUPPLY CHAIN NETWORKS

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ABSTRACT
The research and business interest to the topic of security enhancement in container supply chains dominated over the last 8 years. At the same time the stakeholders looking for the solution not to overload the trade lines with additional security related expenses. Many alternatives based on smart container security devices (CSD) and electronic seals have been examined and extensively tested since 9/11. Nevertheless, undefined electronic seal's status on the world market and manipulations with international standards for such devices involve many discussions about when, how and what type of seal will be most effective and secure for container logistics purposes. This research has a purpose to investigate current issues and to classify the coming up challenges and solutions for worldwide implementation of CSDs in the container supply chain networks with the aim to enhance the security and safety of container transport systems.

Keywords:
Container security devices, e-seals, supply chain security, container logistics

INTRODUCTION

Container logistics is one of the most important activities within global trade flows. The increasing number of container shipments causes higher demands on the seaport container terminals, container logistics, and management, as well as on technical equipment. An increased competition between seaports, especially between geographically close ones, is the result of this development (D Steenken et al., 2005). Insensibly this process becomes more and more complex and risks (e.g. security risks) grow. The interactions of complex logistic transport systems have strategic impact on systems' security and efficiency.

Recent surveys show that many executives from the supply chain and logistics industry consider cargo theft as the main challenge to supply chain security, while safeguarding against a terrorist attack is slightly less important. The Federal Bureau of Investigation has estimated that the cost of cargo theft to the US is between $15 billion and $30 billion a year (G Carroll, 2009). As the economies of the US and the EU in terms of GDP are equal it is not unrealistic to estimate that the cost of cargo theft in the EU is in the same order of magnitude. Container security device is an important element of the complete solution for securing and improving of visibility into shipments. CSDs allow importers, shipping companies, port officials and customs inspectors to determine, without a physical inspection, whether the container has been tampered with and the security of the container compromised. Nevertheless, it is unlikely the world's ports and ocean carriers, or U.S. importers, will invest in RFID seal and reader infrastructure until the International Standards Organization (ISO) issues an e-seal standards (S Barlas, 2005).

Initially, active RFID electronic seal technology was the only one being discussed. Although, it is still the most popular technology for e-seals, there several other advanced possibilities to secure the containers. Another electronic seal technology that has materialized utilises "Zigbee" technology. Zigbee performs like WiFi and allows the seals to interact with location and satellite or GSM communication devices (RS Kirk, 2010). In the case of Zigbee usage the electronic seals system does not need huge infrastructure constructions and investments. Additionally GPS technology can provide great visibility for container flows. However, the costs challenges and ROI factor for investments in more advanced tracking possibilities should be considered (K Daschkovska and B Scholz-Reiter, forthcoming 2010).

CASES OF CSDS UTILISATION IN REAL TRADELINES

There are some valuable commercial and scientific trials to adopt the CSDs and e-seals for the real tradelines in the world practice. The most of tested electronic seals' systems are based on RFID technology supported additionally by GPS/GPRS technology.

SaviTrak(TM) customers in Asia and South America are discovering that the real-time data the system captures from shipments tagged with active RFID e-Seals enhances security visibility, speeds clearance by their countries' Customs authorities, and reduces in-transit inventory costs (2008).

The Emprevi Ltda., a logistics and security firm, identifies that the Savi Networks system has cut security costs in Colombia by $300 per container trip for its customers, which include Johnson & Johnson, Pfizer and Cadbury Adams. Western Digital, a leader in information storage products, says that per-trip costs have been reduced by $40 for point-to-point shipments from its manufacturing facilities to Royal Thai Customs authorities in Bangkok because the automated security devices speed collaboration and government clearances (2008).

Another project INTEGRITY (Intermodal Global Door-to Door Container Supply Chain Visibility) aims at supporting logistics operators in Business-to-Customs cooperation processes and investigating how to integrate innovative technologies (container security devices) under the consideration of new EU security regulations (N Meyer-Larsen, 2009).

The biggest container ports in the world, namely Singapore, Kaohsiung in Taiwan, Rotterdam in the Netherlands, Busan in South Korea and the ports of Los Angeles and Long Beach, have already adopted RFID projects, in particular, testing e-seals abilities for cargo tracking (L Seymour et al., 2007).

Officials at Kaohsiung Harbor, Taiwan's busiest port, have introduced the seals with EPC Gen 2 chips to improve security and reduce the need for officers to escort cargo containers (D Friedlos, 2009).

The projects were focused on various advantages from RFID system implementation in port environment, like greater efficiency by shortening the time for container checking and management through the port by using active RFID e-seals (J Collins, 2005), the issues of congestion and security in the ports (T Nguyen, 2006) or improving the security of containers destined for the USA, with more stringent security requirements (M Clendenin, 2005). Their results show that smart RFID e-seal with its multifunctional ability can be effective for logistics purposes and applications in container supply chains/container ports. Nevertheless, even the anticipated solutions for integration of CSDs in supply chains are proposed only for the particular trade lines and based on the single container tracking devices. Thus, the question about global e-seals and CSDs implementation is still open.

MAIN CHALLENGES FOR CDSs IMPLEMENTATION

Many solutions based on smart locks and seals have been examined and extensively tested since 9/11. Most of the current proposed solutions focus on the electronic lock, seal, and sensor on the container door. They do not address the problem of intrusion through other surfaces of the containers not touching the lock and seal or gasket or the contents stuffed inside the containers. There is a list of the basic challenges for standardized e-seals (2005b):

- Impossible to inspect all of the containers or even 10%.
- No way to know if tampering occurs during transit and too late to prevent loss upon arrival at unloading port.
- Cannot be sure whether any contents may contain weapons of mass destruction.

A lack of standards seems to be a major issue hindering their applicability to international trade flows. A further barrier is the acceptability and cost of E-seals to the container industry. Regular use of seals requires new software connections and container sealing procedures, which could slow acceptance (E McCormack et al., 2009).

Regarding (2005a) it is still remains technical challenges despite the increasing attention to RFID applications. The use of radio waves obviates the needs for a clear line-of-sight placement of a container door with RFID seal, because metal sides of the container reflect electromagnetic energy. This often results in decreased identification rates of seals. Electromagnetic interference from other nearby transmissions in a port area can also affect the tag performance and tag to reader communications. Physical effects such as reflection and diffraction may also affect tag performance. Inconsistent interoperability across various RFID systems, companies, and countries also presents a challenge to the wide-scale development and deployment of RFID technologies.

Standardization issue

Technical standards, frequency, and power levels are critical issues for successful global interoperability of RFID systems. There are several efforts underway to develop and refine technical standards for tags and readers, and common standards remain a goal. Likewise, differences in operational frequency ranges, allowable transmission standards, and allowable power limits in countries continue to serve as operational constraints (K Domdouzis et al., 2007):

The current research and development of future RFID capabilities moves towards the processors fabricated with new conductive materials or use of organic microprocessors for RFID tags and other applications. For example, the National Institute of Standards and Technology is looking at the technical feasibility of replacing silicon or inorganic materials in RFID devices with mostly or wholly organic materials such as plastics. This and other ongoing research in materials and tag and chip design, fabrication, and production will result in more robust and functional tags over time (2005a).

Container transport is an open system with a broad variety of often unknown actors who contribute to the services in the transport chain. The owners' code register of Bureau International des Containers in Paris notes more than 1600 owners and operators of containers using their world-wide unique code to establish identity for their containers. Standardization is a vital condition of the current efficiency of the container transport system. Standardization is needed for security actions as well. The Customs Convention on Containers (Geneva 1972) defines that a seal for container transport under customs seal must be approved by the national Customs Administration concerned. This regulation has, in the end, produced several 1000s of different seal designs. Under such condition, it would be most difficult to ascertain whether a seal has been attached by an authorized party or been replaced somewhere under way (C Seidelmann).

The existing standards for electronic seals are developing by the International Organization for Standardization (ISO). Regarding ISO/IEC 19762, Parts 1 and 3, ISO 17712 e*lectronic seal is "read-only, non-reusable freight container seal conforming to the high security seal defined in ISO 17712 and conforming to ISO 18185 or revision thereof that electronically evidences tampering or intrusion through the container doors"(2006b)*. The ISO 18185 e-seal standard is close to complete and in a little while being available as a useful tool for solution developers and end users. Some basic principles of e-seals have been agreed on meanwhile: the standard electronic seal will be an attachment device fixed to (or integrated into) the mechanical seal that secures the door of the container and programmed with a standardized set of data with the following coded information (C Seidelmann):

- Seal ID number
- Manufacturer ID number for the seal
- An indication of the time when the seal had been closed and when it had been opened
- A bit that indicates an eventual tampering of the seal.

The 18185 system consists of the three distinct components: e-seal, LF transmitter, and reader. The main feature of the system is their dual frequency operations. The strength of a seal is measured with tests based on impact, shear, bend and tensile strength. The values, the measures of strength, reflected numbers in use by major customs authorities. For example, in the EU-China Customs project (SSTL – Smart and Secure Trade Lanes) from DG TAXUD (Directorate-General for Taxation and Customs Union) has already started to test security procedures for intermodal transport in door-to-door supply chains (2004).

Another RFID technology critical issue is a powering the container for batteries tags. Not every port of call offers charging facilities. Some have proposed solar-panel or self-charging devices, but these may be damaged during rough handling of a container, not to mention the logistics of strategic panel placement required to capture sunlight. No one has satisfactorily solved this problem (L Tan and K Raguraman, 2007). To date, the common interoperability among e-seals and readers manufactured by different vendors is additional restrictive factor for national and international adoption of e-seals. For RFID CSDs and e-seals compatibility and exchangeability of RFID components can bring the costs also down (N Wu et al., 2006).

Political issue

Another milestone in global e-seals implementation process is political issue. There are two kinds of political issues. The first is international and national spectrum regulation, which includes spectrum allocation and power and duty cycle regulation; this is an issue in part because there is no global frequency set aside for RFID logistics applications. The second political issue is about commercial interests, as different companies aim for market advantage (M Wolfe, 2002).

Therefore, undefined electronic seal's status on the world market and manipulations with international standards for such devices involve many discussions about when, how and what type of seal will be most effective and secure for container logistics purposes. The debates took a long time and there still no solution or trade-off between customs authorities and business sector, between manufactures of e-seals and standardization institutions regarding technical capabilities of security devices and logistics applications of it.

Costs challenges in the processes of CSDs implementation

Increased container and port security will not come without additional costs, and it does not refer only to the money that the government must invest to increase security. It is essential to balance port and container security with economic efficiency of cargo flows. While port security is the crucial part of the competitive maritime transportation system, too much security can damper trade and leads to a loss of a sense of freedom and to feelings of insecurity (J Firestone and J Corbett, 2003).

Maritime transportation and logistics activities traditionally have been among the largest costs in international trade. But in contrast to that, the most significant advances in modern logistics have not been in cost reduction, but in improved processes to move goods and materials between nations in a timely and seamless manner (R Banomyong, 2005). The implementation of CSI and other security initiatives have also placed an increased trouble in terms of processes and costs for all the players in global supply chains. This means that for CSI to be fully sustainable as a process in global supply chains, the financing of CSI must also be equitable or fair. There are two possible sources for financing CSI (R Banomyong, 2005):

- Payment by users
- Public sources.

Payment by users
A tax or a fee can be charged by the relevant authorities. This specific fee can be collected to finance the extra process, equipments and technology used for CSI. The use of appropriate INCOTERMS will become critical in deciding whether the exporter or the importer should pay this specific fee.

Public sources
Financing can be national and international where each government is responsible for all security initiatives within its borders. In this case the most developed countries would already have security equipment. In place while the developing countries would have to invest a significant amount in order to achieve acceptable levels of security. The international financing could take place if the countries, such as the US, provide a grant to the implementation of CSI around the world (R Banomyong, 2005). On the level of the public financing there is always the risk of not achieving the desired level of security in global supply chains. Regarding the third option, the bilateral financing it is necessary to mention that important to achieve also the financial sustainability after implementation of security measures in global transport network. However, to finance the security measures such as e-seals or SCDs from whatever sources is not guarantee the global supply chain security.

Understanding the finances of current intermodal container tracking first requires an understanding of incentives, investment values, and returns. In practical terms, this means the cost of the equipment and the detention charges applied to keeping equipment longer than the specified free period (S LeMay et al., 2001). Once these elements of the system are well understood, the value of better tracking systems can be evaluated.

Nevertheless, any technological advancement to enhance security must also stimulate trade by reducing the cost or increasing the efficiency of operations. Therefore, integrating a modular tracking, seal, and sensor system utilizing RFID and GPS into the container structure will both increase container security and optimize trade (A Balog et al., 2005). Its success depends on business/government partnerships and international implementation. It must be partnered with stringent initiatives that enhance information exchange and security of the physical and personal components of the supply chain.

DNV (Det Norske Veritas) Consulting international company has done the study for European Commission regarding estimating the general economic impact of international and European programs towards improving and especially investing in transport security in EU (2005c). The DNV have analysed the effect from implementing high security seals, compliant to ISO/PAS 17712, for containers export to outside the EU if seal has a cost of below 0.75 Euro a piece. It is assumed that 80% of intra cargo (2 billion tons per year) is subject to the seal programme and an average cargo unit weighs 20 tons the number of seals needed to implement an EU seal program will be 80 million investment. It is assumen that it takes 2 minutes to mount and dismount such a high security bolt the additional expenses for industry would be in the order of 150 million Euros (2005c).

The equipment costs can be broken down into the cost of the container, the seal, the RFID tag, and the smart box. The investment for new shipping containers is between \$7,000 and \$40,000, depending on the size and its function (dry goods or refrigerated goods) (A Balog et al., 2005). High-security mechanical seals cost between \$0.50 and \$2 per seal depending on the material employed (P Tirschwell, 2005). Electronic seals developed by Savi Technology, used by the Department of Defense and tested in a pilot program with the Asia Pacific Economic Cooperation (APEC) Secure Trade in the APEC Region (STAR), have a value between \$300 and \$400 (A Balog et al., 2005).

The designs of reading infrastructure of e-seals have as well a principal impact on the range that the system can be effective and on the ability of the devices to communicate in complex environments such as container yard / terminal gate area. The differences in effective reader range have a key impact on the infrastructure required to cover a large reading area (L-P Chin and C-L Wu, 2004, S Park et al., 2005). This is an important trade-off that will determine the total infrastructure cost of an installation. Less complex systems will have a lower potential cost per reader; however multiple readers will likely be required. More sophisticated devices could have greater potential investment per reader but only a single reader might be required (L Chin and C Wu, 2004).

Mandating issue

15 October 2008, a mandate issued by the United States Customs Border Protection (CBP) became effective requiring all US inbound maritime container s to be secured with an International Organization for Standardization ISO/PAS 17712 bolt seal (HS U.S. Customs and Border Protection, 2008). However, many shippers and container carriers have been using these bolts for years with no appreciable effect (G Carroll, 2009). These seals are easily counterfeited, and their main advantage seems to be that they are inexpensive. The technology is available now to develop a single-use, disposable, inexpensive, versatile and reliable e-seal. Part of the argument put forward by the DHS for not using e-seals is the concern by both government and industry about the costs of the e-seals, the costs of an extensive and expensive RFID infrastructure, the logistics of returning reusable e-seals and responding to 'false positive' alarms caused by defective and unreliable e-seals.

DISCUSSION and CONCLUSION

Nowadays, up to 80 per cent of container terminal operations are undertaken by private operators, who use the latest information and communication systems (ICTs) (2006c). The public sector needs to adapt to new business practices and introduce appropriate technologies for securing of transportation process. However, ICTs will be beneficial only if existing administrative and commercial practices are overhauled prior to the computerization of procedures (2006c).

CSDs can present a wide range of attractive and useful functions such as time and cost savings and business intelligence for logistics stakeholders (K Daschkovska and B Scholz-Reiter, 2008, J Zaino, 2009). Nevertheless, there are still some challenges in worldwide adoption of smart security systems. The first discussion point is what kind of technology should be used as a worldwide standard of e-seals or CSDs. This discussion has a substantial importance for the next issues: what kind of infrastructure need to be established and what kind of functionality one could obtain from the device (2006a). The infrastructure for RFID CSDs does not presently exist, and need to be installed on thousands of different properties. Another actual issue for e-seals global implementation is international ISO standards for the devices. It is still an open question what the product needs to do; what specific events must be captured and recorded; is capturing entry through the doors enough or must it detect entry into the container through the walls, ceiling or floor; does the device have to detect conditions other than entry intrusion? No doubt, that better security and greater visibility will bring a lot of value to the global trade growth. But first of all, the governments and industry have to archive the equilibrium from security requirements and variety of businesses benefits, before to set all these specifications for container security devices and begin the process of global CSDs implementation.

REFERENCES

(2004) "Agreement with the United States of America on intensified customs cooperation on container security", by EU Directorate-General for Taxation and Customs Union, Brussels, IP/04/525, 22nd April 2004. Available at: http://ec.europa.eu/taxation_customs/resources/documents/usa_agreement-csi_en.pdf.

(2005a) "Radio Frequency Identification: Opportunities and Challenges in Implementation", by US DOC. Available at: http://www.zdnet.de/radio_frequency_identification_opportunities_and_challenges_in_implementation_download-39002355-60146325-1.htm.

(2005b) "Secure Cargo Container and Supply Chain Management Based on Real-Time End-to-End Visibility and Intrusion Monitoring": Available at: http://www.avantetech.com/whitepapers/white-papers-and-reports-on-rfid/.

(2005c) Study on the impacts of possible European legislation to improve transport security Final report: Impact assessment, Report for European Commission DG TREN. DNV Consulting, Antwerp-Brussels.

(2006a) Comments on the "International Container Standards Organization" and its Effort to Propose New Standards for Container Security Technologies. *World Shipping Council.*

(2006b) Freight containers - Electronic seals - Part 7: Physical layer. ISO 18185-7, ISO/TC 104/SC 4.

(2006c) "Report of the expert meeting on ICT solutions to facilitate trade at border crossings and ports. Expert Meeting on ICT Solutions to Facilitate Trade at Border Crossings and Ports", by United Nations Conference on Trade and Development, Geneva, 16-18 October 2006, 20 November 2006. Available at: http://www.unctad.org/templates/meeting.asp?intItemID=1942&lang=1&m=11898.

(2008) Savi Records 25,000th e-Seal Shipment on SaviTrak System to Monitor Cargo Security and Location Rfid Ready.

BALOG, A., LIM, J. J. & NETTLETON, K. (2005) Riding the wave on ship container seal and tracking systems. *2005 Symposium on the Global Commercialization of Environmental Technologies. University of Washington.*

BANOMYONG, R. (2005) "The impact of port and trade security initiatives on maritime supply-chain management", in *Maritime Policy & Management,* 32 (1), 3-13.

BARLAS, S. (2005) ISO Reconsidering E-Seal Specification. In *RFID Journal* Available at: http://www.rfidjournal.com/article/articleview/1696/.

CARROLL, G. (2009) "Seal Launch", in *Cargo Security International,* (February / March 2009), 52-53.

CHIN, L.-P. & WU, C.-L. (2004) The Role of Electronic Container Seal (E-Seal) with RFID Technology in the Container Security Initiatives. *Proceedings of the 2004 International Conference on MEMS, NANO and Smart Systems.* IEEE Computer Society Washington, DC, USA.

CHIN, L. & WU, C. (2004) The Role of Electronic Container Seal (E-Seal) with RFID Technology in the Container Security Initiatives. IEEE Computer Society Washington, DC, USA.

(2005) "South Korea rolls out RFID for cargo port": Available at: http://www.eetimes.com/news/semi/showArticle.jhtml;jsessionid=N0HUJIXK21UHWQSNDLPSKHSCJUNN2JVN?articleID=60407369&_requestid=75964.

COLLINS, J. (2005) Korean Seaport Tests RFID Tracking. RFID Journal.

DASCHKOVSKA, K. & SCHOLZ-REITER, B. (2008) "Electronic seals for efficient container logistics", in HAASIS, H.-D. K., HANS-JÖRG; SCHOLZ-REITER, BERND (Ed.) *Dynamics in Logistics. First International Conference, LDIC 2007, Bremen, Germany, August 2007. Proceedings.*, Springer Verlag.

DASCHKOVSKA, K. & SCHOLZ-REITER, B. (forthcoming 2010) "How can electronic seals contribute to the effeciency of global container flows?", in KREOWSKI, H.-J. S.-R., BERND; THOBEN, KLAUS-DIETER (Ed.) *Dynamics in Logistics, Second International Conference, LDIC 2009, Bremen, Germany, August 2009. Proceedings.* Springer Verlag.

DOMDOUZIS, K., KUMAR, B. & ANUMBA, C. (2007) "Radio-Frequency Identification (RFID) applications: A brief introduction", in *Advanced Engineering Informatics,* 21 (4), 350-355.

FIRESTONE, J. & CORBETT, J. (2003) Maritime Transportation: A Third Way for Port and Environmental Security.

FRIEDLOS, D. (2009) "Taiwan Customs Officials Adopt RFID-enabled Container Seals", in *RFID Journal*.

KIRK, R. S. (2010) "How do electronic seals fit into the future supply chain? Is the future now?", in *Port Technology International journal,* (40), pp. 108-110.

LEMAY, S., CASSADY, R. & VIATOR, J. (2001) Tracking and Positioning Software: A Market Need, Value, and Cost Analysis. In *National Center for Intermodal Transportation. Mississippi State University.* Available at: www.ie.msstate.edu/ncit/ncitwebupdate/Version2LeMayFinalProject.

MCCORMACK, E., JENSEN, M. & HOVDE, A. (2009) "Lessons from Tests of Electronic Container Door Seals", by 09-0821. Available at: <http://pubsindex.trb.org/orderform.html>.

MEYER-LARSEN, N. (2009) "Heading towards transparency: creating supply chain visibility to improve container transport", in *PORT TECHNOLOGY INTERNATIONAL,* 41 (Sept.), pp. 109-111.

(2006) "Port trucks get RFID'd": Available at: http://fleetowner.com/news/topstory/port_long_beach_los_angeles_rfid_truck_pierpass_011306/.

PARK, S., LEE, M. K., KIM, D. K., PARK, K., KANG, Y. S., LEE, S., KIM, H. & CHUNG, K. (2005) "Design of an Authentication Protocol for Secure Electronic Seals", in *Proceedings of World Academy of Science, Engineering and Technology,* 10, pp. 47-51.

SEIDELMANN, C. "Enhances Security in containerised trade: The contribution of standardisation", in *Workshop "Sicherheit der Internationalen Container-Versorgungskette", ISO TC 104 SC 4 Freight containers*.

SEYMOUR, L., LAMBERT-PORTER, E. & WILLUWEIT, L. (2007) RFID Adoption into the Container Supply Chain: Proposing a framework. *The 6th Annual ISOnEworld Conference.* Las Vegas, NY.

STEENKEN, D., VOSS, S. & STAHLBOCK, R. (2005) "Container terminal operation and operations research — a classification and literature review", *Container Terminals and Automated Transport Systems.*

TAN, L. & RAGURAMAN, K. (2007) RFID Centre Tests Live Supply-Chain Application. Radio Frequency Identification tagging offers great value to manufacturers and other parties involved in the supply chain. In *INNOVATION: the Magazine of Research and Technology* 6 (1), Available at: http://www.innovationmagazine.com/innovation/volumes/v6n1/coverstory3.shtml

TIRSCHWELL, P. (2005) "An Opportunity from Container Seals", in *Journal of Commerce,* 6 (6), 54.

U.S. CUSTOMS AND BORDER PROTECTION, H. S. (2008) Container Seals on Maritime Cargo. In *Federal Register* 73 (153), 46029-46030. Available at: http://edocket.access.gpo.gov/2008/pdf/E8-18174.pdf.

WOLFE, M. (2002) Technology to Enhance Freight Transportation Security and Productivity. *Intermodal Freight Security and Technology Workshop.* Long Beach, California.

WU, N., NYSTROM, M., LIN, T. & YU, H. (2006) "Challenges to global RFID adoption", in *Technovation,* 26 (12), 1317-1323.

ZAINO, J. (2009) "RFID-Enabled Electronic Seals", in *RFID Journal,* (July/August), pp. 29-34.

RAPID EXPANSION CAPABILITY AND EFFICIENT MANAGEMENT IN DE-CENTRALIZED SME SIZED MANUFACTURING COMPANY

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ABSTRACT
Earlier, in SME companies the focus has been mainly on capacity allocation and production planning, not so much on flexibility, anticipation and prepared processes. Nowadays many SME are considered to be quite flexible, but somewhat area / location constrained. As such there has not been a need for understanding of centralized management and steering of decentralized business units on SME level. In this case study a new operational model (in SME company size) was found, that allows rapid business expansion and efficient resource allocation over decentralized production unit network. The model is based on a concept of (possible) firm acquisition, management streamline process, worker acquisition and re-education, working method modernization, centralized production steering over the whole factory network for efficiency maximization and efficient resource allocation. This model allows profound partner relationship, in which the partners have shared goals and decision-making processes aiming at mutual strategic benefits. Nowadays the focus on SME has been diverted from plain capacity allocation to flexibility and anticipation, but typically SME are still limited on resources to change their company structure to reflect changes on main suppliers' side. Lately, these limitations have been clear, in cases where the main supplier expands operations on distant locations (e.g. other countries). This research case reports an subcontractor business growth model, that goes around of the limitations and as a model is considered to be unique, considering the size of the sub-contractor.

Introductions

At the end of the 1990's companies started to outsource more and more of their non-core business processes (Prahalad and Hamel 1990). In those days the main idea was to add operational efficiency. Typically out-sourcing was not seen as a mean to add long term strategic winnings (McIvor et al. 1997). As Logistics service operators and SME sized subcontractors started to offer value-added services and business support concepts, also the strategic partner point of view started to grow in manufacturer side.

In the time these value-added services started to surface, the manufacturing industries were on fast growth phase. During the fastest increase in demand in the new millennium, reduced material availability was a true challenge in the Finnish machinery industry. And as a result e.g. delivery times promised by sales departments to the customers had to be extended due to over-crowded order books. As a result some companies did lose their market share. The over-crowded order books did not stop on the manufacturers. Also the sub-contractors were in trouble, when they tried to respond to the ever expanding demand. As result manufacturers were not able to respond on the growing demand as they were not able to obtain all the needed sub assembly parts, from their sub-contractors. As a result of these times, the amount of outsourcing, growing amount of added value services as well as the wide supply network usage in high demand times has had its own part to the current structure of supply and production networks in Finland.

Production in the current Finnish machinery industry is highly decentralized into a subcontractor network. This means, that functionality of the subcontracting chain can be a vital competitive advantage. And because of this seamless cooperation between a manufacturer and subcontractors can offer a strategic edge in many cases. Cooperation with supply chain partners is generally regarded as a good means to improve the performance of the supply chain and increase the supply chain's business (Lambert et al. 1999). In a profound partner relationship, the partners have shared goals and decision-making processes aiming at mutual strategic benefits (Stank et al. 2001). Typically, cooperation on supply chain, means some sort of synchronization on supply chain processes to achieve higher efficiency on supply chain operations. On another hand, supply chain synchronization is not a goal in itself, because it usually makes the activities more complex. Therefore, a counterpoint to synchronization is simplifying and stabilizing activities (Kambil 2008), which is also the one method applied by the case SME company on this research case.

Manufacturers are nowadays diverting their interest on SME from capacity allocation to flexibility and anticipation, the problem on SME side is typically resource limitations so they are not generally able to respond on this interest. Still the SME sized sub-contractors may well be the key players for any future expansion plans the manufacturer might have. As this problem is quite common in Finnish context the research question was raised; how SME sized sub contractor can respond to the expansion of the main supplier and expand its own size simultaneously? To answer this question, A case study research was carried out covering a SME subcontractor with very innovative expansion strategy. With this model, this sub-contractor has been able to build up new rapid business expansion and efficient resource allocation schema. The model allows expansion trough utilization of a decentralized production unit network. The authors of this case report are not aware of any other similar cases; especially any cases connected to a SME sized subcontractors.

Research methodology

The research process was a case based qualitative research. The case research method was selected as this study seeks an understanding of a phenomenon in the real world over which investigators have little or no control (Yin, 1994). Also (Lee, 1989) states that a single case study has a rigorous method in examining a phenomenon that exists in a real-world setting. The case material was gathered from one SME sized company, servicing simultaneously multiple manufacturers. A case study is defined as an empirical inquiry that examines an existing phenomenon within a certain real life context when the boundaries between the phenomenon and context are not clearly obvious and in which case multiple evidence is used (Yin, 1994). (Yin, 1994) states that when investigating key events, that may have little theoretical background, a researcher might select a single setting that provides the best representation of the phenomenon.

This research report is a case report about subcontractor and its business growth strategy as a service model for manufacturer. In this case a manufacturer is defined as a producer of an end product (on b2b markets). A subcontractor is a contractor performing specific tasks for the manufacturer. The case study subcontractor produces steel and metal parts for manufacturers as defined on business agreements.

The case study was made on a SME company that has been found out as part of a larger research project covering synchronization issues on manufacturing industries area. This case company has shown that a SME company can be innovative (in a field of business area that is generally been considered as old fashioned) and be able to push new solutions to a problem that is generally been considered "too big" for a SME sized company to be able to solve.

Research data was collected trough case company CEO interviews, on site study of the case company management methods and by interviewing manufacturing industries servicing ICT service providers. In start of the research the current understanding was that SMEs are flexible and able to adapt to corporate contractors, but the SMEs may not be able to anticipate moves of their main suppliers.

The limitation of this case study is that this study is a single study case. As such the amount of generalization is restricted. Furthermore, working models, business environment and the products of the case company can limit the direct comparison of the study result on other industry environments. Also, the fact that the study was performed in the Finnish environment regarding only one industry might limit the applicability of the business model on other business areas.

Research case environment description
Finnish machinery industry's current situation on manufacturer & sub-contractor synchronization was studied as a background by interviewing Finnish manufacturer and subcontractor pairs. The background study works as reference when making the observations and conclusions of the lessons learned from the case. The interview form used in the background study was created by the companies as well as the authors. The companies reviewed the interview questions beforehand the official interviews and offered comments to enhance the interview process and questions. This improved the clarity of the questions and assisted the interviewees in understanding the questions and ensured that the questions were understood in the same way. The questionnaire was mainly structured with few free-form questions. The free-form section included open questions (Denzin and Lincoln 2005). Structured part followed a predefined list and the interviewees selected one of the provided answer possibilities. Following areas were used for the questions: concurrent engineering process, logistics process, manufacturing planning and control process, shared business plan and procedures (contract process), as well as management of processes. A total of 24 companies, forming 12 pairs, were interviewed by phone. The questions were same for all and the questions were submitted to the respondents in advance.

The method to study companies in pairs was selected because synchronization deals with activities occurring between companies and because the authors wished to compare the views of manufacturers and subcontractors regarding the current level of synchronization. The whole background study with detailed analysis and findings is reported on (Hietajärvi et al. 2009). In this case paper only the most important parts for this case of (Hietajärvi et al. 2009) are reported. This background study report should give the reader a clear picture on what is the state of the Finnish machinery industries subcontractor and manufacturer relationships in 2009.

On the concurrent engineering process study part, it was found out that the subcontractor and manufacturer rarely had access to shared real-time engineering documentation. This limitation seems to be a result of incompatible of the ICT system used on different companies. On some cases the information is not shared at all (e.g. manufacturer does not want to share the information as the subcontractor is serving manufacturers competitors too). But still, both the subcontractors and the manufacturers consider that the partner fairly well offers information pertaining to the product engineering process at the right time. However, both parties felt that the sharing of information and the quality of information could be improved in the future.

In the part considering the visibility of partner’s logistics process, most of the manufacturers experienced that they have poor visibility to the subcontractors’ logistics processes. As for the information influencing delivery decisions, both parties considered that information is available from the partner at the right time and on time.

In the part considering matching demand forecasts and capacity, it was found out that matching takes place on case-by-case basis (e.g. subcontractor trust some of the manufacturers forecasts and in case of another manufacturer the subcontractor forecast the demand by themselves disregarding the manufacturers forecast). The real-time information of changes in demand from the manufacturer to the subcontractor was available too late on some cases, from the subcontractors’ viewpoint. Subcontractor had to order or manufacture components or assemblies for its clients well in advance because of the long order delivery or manufacturing lead times. In short time frames, information required in controlling manufacturing activities was exchanged from the partner to another at the right time. Manufacturing control information was changed between parties, but the communication was not constant (e.g. information was delivered only on request). In the respondents' opinion, their partner offers information required to control manufacturing in a slightly poorer manner than information influencing logistics processes / delivery decisions.

In the part considering officially agreeing on shared activities, most companies had made agreements on shared practices, risks, communication and responsibilities but only unofficially. Only few companies had signed official agreements or shared business plans. Several interviewees stated that a written agreement is necessary in case of problems. Not so many companies had a shared business plan. This means, that the companies do not see each other as an important partner or the plan might be seen as too tight attachment to each other. Too tight in sense, that it might limit future possibilities for different change plans. On the another hand, the business growth model reported on this paper shows how a SME sized company can be a valuable business partner for a manufacturer that has e.g. future expansion plans. The expansion capability of the sub-contractor might give the needed additional reason for the manufacturer to make the shared business plan.

About business relationship and win-win situations, both parties felt that the cooperation rewards them fairly equally. Companies mostly agree that there is a win-win capability and there are no major disagreements. Considering shared production strategies, more than five years ahead, none of the company pairs had a shared long-term production strategy. Several companies stated that even there is no official production strategy on paper, there is a long history together and practice have proven that there is still some sort of a strategy. The operations are developed together, but companies felt there is room for improvement. Most importantly, on the topic of awareness of cooperation costs, the respondents were not very familiar with the cooperation costs arising from the cooperation. The subcontractors were slightly more aware of the costs, than the manufacturers. The manufacturers did not receive clear information on what exactly was included in the product price and how the related costs were generated.

Subcontractor case description

This chapter describes the case company and its business model which allows the expansion capability. Earlier this SME sized sub-contractor has been working as typical SME sized sub-contractors do in Finnish industry context. In past few years, company has been building up corner stone's for this new growth strategy, including flexible, multi parameter, resource management methods. In addition, this company has been designing new efficient work management model, which uses scarce resources on middle management level and highly utilizes available work resources (man hours) on operational level. Trough these base components and well defined corner stones with the efficient manufacturing strategies and flexibility models on house, the company was able to start to think growing up in size and work towards general model, which would allow fast acquirement of new sites trough assimilation to these corner stone working methods and models.

The basic components of the expansion model are presented in **Figure 1**. The central management hub, in the picture, is the base point of the operations. It is the center where business support level and management level operations are carried out for all operational sites of the company. In essence it is a central management hub. For example, time tables for all subcontractor sites are defined trough production planning tools used on the central hub. The work loads of the sites are divided on the hub to support steady capacity and resource allocation, when ever possible.

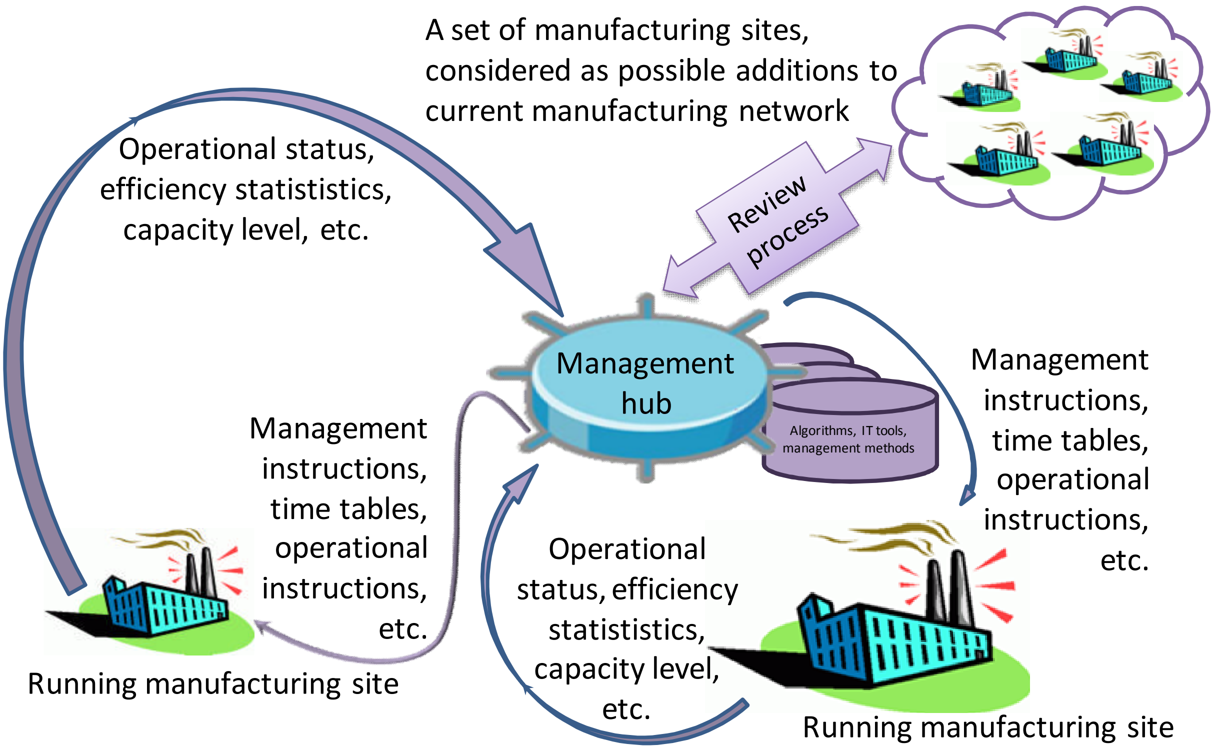

Figure 1: General information exchange and structure of the expansion model

In addition to operational steering and planning, also all payment and financial operations are handled by the management staff located on the hub. Company CEO operates on sites and on the hub to steer the company. CEO also manages all contracts with the manufacturers and makes all strategic steering decisions considering the future of the company. Operational level information is kept on the central hub, if this information is needed on company sites it is fetched over Internet to the sites. The handling of the work flows is done by the few middle managers on the operational sites.

All the management levels of the model are presented in **Figure 2**.Trough applying only these scarce resources on management, it is possible for the sub-contractor to make fast acquirements of new sites. This is the key element for the subcontractor to be able support the growth of the manufacturer.

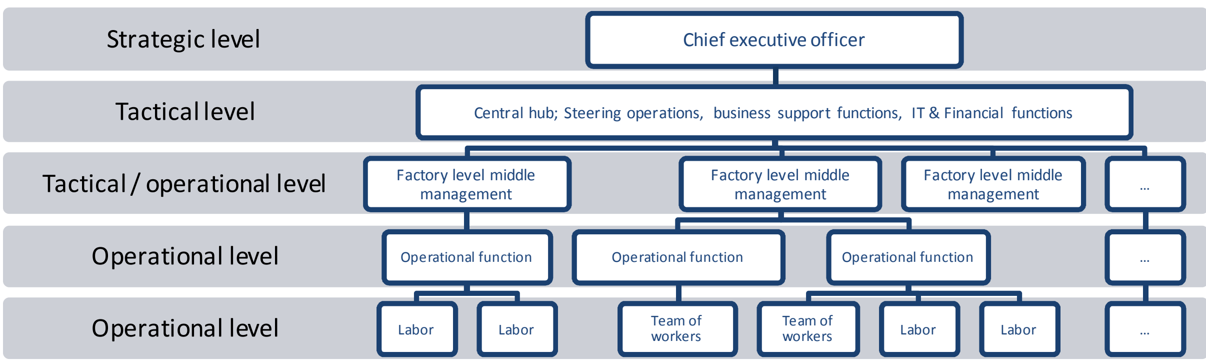

Figure 2: Different management levels and functions on the expansion model

There aren't any high level or low level managers on sites. All management task are handled by the central hub, except for e.g. work order allocation for the work force etc.

and site specific development which is handled by the middle managers on the sites. Logistics operator / transportation company agreements, financial contracts, material acquirement agreements etc. are negotiated by the CEO or by the key personnel's working on the central hub, depending on case and decision making needs.

The management burden is truly light weight on this model as the management itself is streamlined. Only the minimum amount of middle management is applied on sites and the rest is handled on the central hub. To manage all the rest from the hub, the persons on the hub have been working in the sites before they start on the hub. People are rotated from the hub on different sites and then back to the hub. This rotation is the key for they fast learning curve of the people steering the company sites. Everything learned on sites is used, when ever possible, in the hub to further enhance the work on other sites. The cycle of rotation is depicted on **Figure 3**.

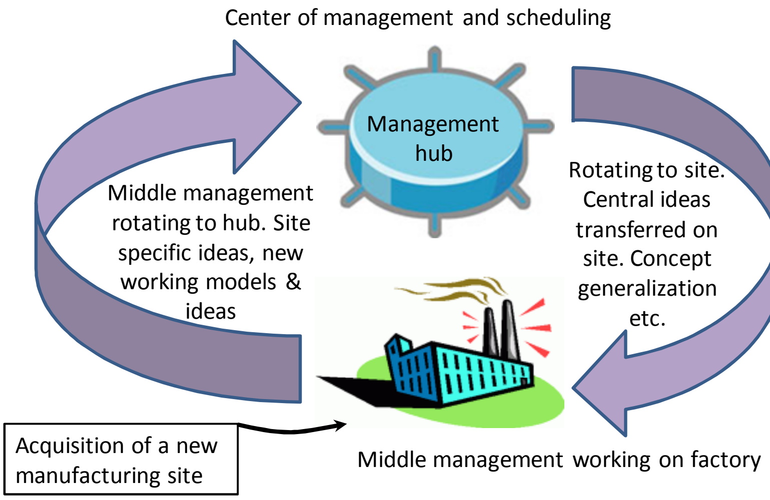

Figure 3: Management level work force rotation program

In addition to manager rotation also, some work force is also rotated from site to the hub and then on another site. This rotation allows processes standardization and work flow simplification on sites. Rotation cycles allow work force self education, which results modernization of work methods all over the sites (as the work force shows their new working methods for their co-workers). Rotation process makes the site acquisition process fast for the subcontractor. E.g. When a new site is purchased the subcontractor educates the on site middle managers to lead using the new model for several months. After this initial time period, the middle managers from this site are transferred on the central hub to steer the site. At the same time managers from the hub are transferred on the site to learn all the details of the site. After the initial cycles, the model returns to the basic cycle as presented on **Figure 3**.

In essence the educational cycle, with all the steering tools available on the hub combined results this growth model. This efficient combination of resource allocation, educational cycles and central management allows efficient daily operations. Because of the model, centralized production steering is possible and the factory network can be efficiency management and the production capabilities can be used wisely. In addition to management advantages, the model allows resource allocation levels, which aren't typical within other models (in SME company scale).

Findings

As a result of this case study a sub-contractor business model was found out that allows fast synchronization between manufacturer and subcontractor after manufacturer's expansion on new country / region. The model allows subcontractor to support manufacturers' expansion by providing synchronization in production, logistics and supply chain management processes between companies.

The model reported in this paper, combines tools for firm acquisition, streamlined management process, working method modernization, worker acquisition and education, centralized production steering on factory network for maximal resource allocation and efficiency. In the start there might be large challenges to implement similar model in different environments, but when the model is up and running, adding new sites on the network is quite straight forward process. It was found out on the background study that the synchronization of the demand-supply chain in the Finnish machinery industry between the subcontractors and the manufacturers seem to be satisfactory. At the same time, the model presented here shows that there is still many areas, where improvement can be achieved on demand-supply chains in this industry area.

When companies have clear understanding of each other's indentions, long term relationships work best. Shared businesses plans make long term planning easier and give companies time to react on changing situations. As the model shows, size of the company does not have to dictate the capability of the company to grow. When the manufacturer trusts that the subcontractor has the tools and willingness to grow, it should enhance the relationship between the companies. Enhanced understanding of business partner allows usage of systematic synchronization approaches allowing problem handling trough well established procedures. With well defined procedures scaling up and down in changing market situations is significantly easier, than what it typically is.

Considering the findings from generalization point of view, there are still some questions. For example, can sub-contractor expand on areas where the cultural and language barriers high. In current development state, the case company has not had any major challenges considering this issue. Which on the another hand does not say, there might not be any problems in the future. E.g. the workload and resources needed for expansion could outweighs the benefits the subcontractor could offer for the manufacturer compared to some new local subcontractor partner with local cultural knowledge. Currently the company has sites only on EU, but the case company does not see any special limitations in example on expanding outside EU limits.

The most important findings of the case were the collection of methods, for the subcontractor to be able to efficiently manage and enhance the work on each site. A possible problem of the model could be a long ramp up time of the manufacturer on their new site. Even if the subcontractor has tools to ramp up on production in fast phase, it is not clear can the manufacturer do the same. The difference in ramp up could result poor resource utilization on subcontractor side. Other risks of the model include the possibility of a rapid falling of demand from the manufacturer, failing on change process from old to new model on new site, problems on controlling of the units' trough remote management executed from the central hub and also the possible financial challenges in case the subcontractor is growing too fast compared to the incoming revenues.

Conclusions

Next study phase should be a test of the model in different industry areas and business settings. The possibilities this expansion model offers for a dyad relationships, it would be really interesting to study the possibilities of the model in a company network environment. Especially because subcontractors need to take into account also their own subcontractor network, in which components are often manufactured before delivery to the manufacturer.

This case study revealed a new concept of how a sub contractor can expand their operations rapidly on new locations (e.g. in side state), nearby countries or even on new continents to respond main suppliers' company expansion and / or competitor take over and new supplier demand situations. Trough revealing this model, main supplier company CEO's can enhance their current business model by investigating the case details and comparing them on their current sub-contractors operational models. Also network business model researcher can find new insights how to configure and upkeep a company that uses a network of business units to respond to main suppliers demand trough operational model analysis of this sub-contractor expansion model.

The model allows profound partner relationship, in which the partners have shared goals and decision-making processes aiming at mutual strategic benefits (Stank et al, 2001). Cooperation itself within supply chain partners is generally regarded as a good means to improve the performance of the supply chain and increase the supply chain's business (Lambert et al, 1999). The risks for the given model include e.g. rapid falling of demand from main suppliers, failing on change process from old to new model, problems on control of the units' trough remote management executed from the central management center. On the another hand when the model is working as planned the possibility for the sub-contractor to be able to support main suppliers expansion plans simplifies and stabilizes activities on supply chain in time of change (Kambil, 2008). Compared to that, even when this model has multiple tools on subcontractor side that allows business growth for both companies, work is still needed in the future. E.g. overall optimization of activities is not directly solved just by applying this business model and might need simplification activities to the model on some cases.

To be able to measure the effectiveness of this model, common performance indicators are needed for both parties to support synchronization of daily operations and demand-supply chains with each other. The lack of a shared long-term production strategy can influence the motivation to synchronies activities, which is one of the risks of the model. As a positive side note, most of the respondent companies of the background study were aware of the fact that overall optimization is important and strive to achieve it in their manufacturer / subcontractor relationships.

Considering the model, the background study bias on logistics visibility on each others supply chain could be narrowed down. Through the central hub it is possible for the subcontractor to give the manufacturers the visibility on their ongoing daily work and by so doing allow the manufacturer to adjust their own production and processes towards more synchronized operations.

Even visibility between the manufacturer and subcontractor allows both parties to use flexible production strategies and also it provides fair balance on the supply-chain when adjustments are needed to be able respond on exceptions on operations. With better visibility, in case of exception, both companies would have better opportunities to adjust on changes. Better visibility allows both companies to flex, which doubles the possibility to succeed on exception management compared to the situation that only one of the companies flexes.

Considering the findings of the background study and the possible challenges on the model, the finding about the communication between the business partners was the most disturbing. It was found out that the communication is considered to be fluent and companies feel that the information available to them is timely and easy to interpret, which is good. But regardless of this, the companies are not always aware of each other's decisions and actions. Comparing this to the expansion model, if the manufacturer does not allow the subcontractor to participate on strategic planning and decision making meetings the manufacturer has about these issues, the subcontractor might not have enough time to be able to respond on the manufacturers needs when the time is on hand to make the final expansion decisions. So, clearly one of the most important factors for this model to work is an early and open communication about future scenarios of expansion plans.

The case is considered a good example how an innovative SME sized company could grow in scale in future on an industry field that is typically considered as old fashioned industry. From the generalization point of view the study is limited as the study concentrated only on one case.

Future research
This research studied only the sub-contractor - manufacturer pairs and their business growth as a pair. In future a company case in which the manufacturer and sub-contractor are served by a logistics service provider should be considered. It would be really challenging research topic to compare the LSP and sub-contractors possibilities to offer expansion services to new areas for the manufactures. Which is more efficient model, good LSP with wide contacts in target area or a sub-contractor which has extremely well knowledge base on manufactures needs and good expansion strategy?

Addition to LSP research case, the model should be researched as a longitudinal study. E.g. possible success factors and problem sources and challenging case factors should be revealed and studied toughly. Longitudinal study should be a good method to clearly show which business settings are the most optimal environments for applying this model.

References

Denzin, N.K.., Lincoln, Y.S. (2005) The SAGE handbook of qualitative research, 3rd edition, SAGE Publications, ISBN: 9780761927570

Hietajärvi A-M, Salmela E., Happonen A., Hemilä J. (2009) ”Demand-Supply Chain Synchronisation in the Finnish Machinery Industry”, LRN Conference - 2009, Cardiff, Wales, 09-11.9.2009, p. 8

Kambil, A. (2008) Strategy crossroads. Synchronization: moving beyond re-engineering. Journal of Business Strategy, Vol. 29, No. 3, pp. 51-54

Lambert, D.M., Emmelhainz, M.A. and Gardner, J.T. (1999) “Building successful partnerships”, Journal of Business Logistics, Vol. 20 No. 1. pp. 165-181

Lee, A.S. (1989), "A scientific methodology for MIS case studies", MIS Quarterly, Vol. 13 No. 1, pp. 33-50

McIvor R.T., Humphreys P.K. and McAleer W.E. (1997), A strategic model for the formulation of an effective make or buy decision, Management Decision, Vol. 35, pp. 169-178

Prahalad, C. K. and Hamel, G. (1990), The core competence of the corporation. Harvard Business Review 1990, May–June, pp. 79-91

Stank, T.P., Keller, S.B. and Daugherty, P.J. (2001) “Supply chain collaboration and logistical service performance”, Journal of Business Logistics, Vol. 22 No. 1, pp. 29-48

Yin, R.K. (1994), Case study research: Design and methods, 2nd ed., Sage Publishing, Thousand Oaks, CA.

THE SUPPLY-SIDE OF THE E-GOVERNMENT IMPLEMENTATION: AN ANALYSIS USING DEMATEL METHOD

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ABSTRACT

Purpose - There are evidences that the developing nations face a number of challenges while implementing electronic government (e-Government). The purpose of this study is to investigate the critical factors associated with the supply-side of the e-Government implementation in Bangladesh.

Design/methodology/approach – A framework for the e-Government implementation from the supply-side perspective has been proposed. It is consisted of nine factors and three higher-level constructs. Data were collected against these factors using 24 respondents who belong to four categories of organisations such as government policy makers and public officials, development partners, implementing agencies, and ICT task force members. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was used to indentify the critical factors of the e-Government implementation and the causal relationships between these factors.

Findings – The results indicate that from the supply perspective the major concerns for e-Government implementation are security, technological issues, and regulatory framework, whereas, the main drivers are political commitment, administrative leadership, and resources. Political leadership directly influences the administrative leadership, funding provision, development of regulatory framework, and privacy issue regarding e-Government implementation.

Research implications – The study suggests a framework for e-Government implementation from the supply-side perspective that will help policy makers to assess the factors of e-Government. The findings provide insights into the criticality of the factors and assist decision makers to develop a strategic action plan for proper e-Government implementation.

Originality/value: Previous studies in e-Government were conducted mainly using case study methodology and qualitative approach. This is one of the rare studies which apply a quantitative approach using data from four categories of stakeholders. The findings of this study can be applied in other developing nations.

Keywords – Critical factors**,** e-Government, DEMATEL analysis.

Paper type- Research paper

INTRODUCTION

There are evidences that a successful electronic-Government (e-Government) can facilitates speedy, transparent, efficient and effective interaction with citizens, businesses and other stakeholders (Scware and Deane, 2003; Bhatnagar, 2004; Lam, 2005). Like in the developed countries, people and businesses in developing nations also require more efficient services from public sectors. Recently, many developing nations have taken initiatives to adopt e-Government. However, the accomplishment of e-Government is relatively slow due to many challenges. Studies suggest that a coordinated effort by political leaders, bureaucrats, and private entrepreneurs is critical to facilitate the growth of e-Government (Bonham, and Thorson, 2001). The purpose of this study is to investigate the critical factors associated with the implementation of e-Government in Bangladesh and to assess the causal relationships between these factors.

LITERATURE REVIEW

The accomplishment of e-Government in developing nations often faces a number of challenges (Backus, 2001; Heeks, 2001; Yigitcanlar, 2003). From the supply–side perspective these challenges can be grouped into three categories such as institutional, resource related, and legal aspects. A brief discussion on these categories is given in the following sub-sections.

Institutional

Institutional factors such as political commitment, administrative leadership and organisational structure are considered critical for e-Government implementation. For instance, Coursey and Norris (2008) and Koh *et al.* (2005) view political commitment and organisational structure as the two key factors for successful e-Government implementation. Similar view is expressed by Kettle (2003). For any reform to materialise, political commitment is the most important success criterion in general, and in developing nations in particular (Ndou, 2004; Mahmood, 2004). CEG (2001, p.7) suggests that 'public sector leaders must embrace e-Government as a tool to transform and improve government and connect it to the people it serves'. According to OECD (2003) the most important ingredient for successful regulatory reform is the commitment and consistency of support coming from the highest political level. Singh (2003) asserts that the top officials within a department are the main driving force. Therefore it is critical that they have a clear understanding of the definition and scope of e-Governments. While political commitment is the milestone of any change, administrative leadership with effective management process is crucial.

Resource issue

Resource including technological, financial and human is critical for e-Government implementation. Daws and Pardo (2003) found that inter-organisational integrated projects often lack sound financing. According to Caffery (1998) sharing projects are often implemented on ad-hoc basis wherein financial and man power supports are not sufficient to sustain these projects. As a consequence, e-Government projects are generally hindered by financial constraint (Edmiston, 2003, Norris *et al*., 2003) which exerts pressure on the implementation process (Coursey, 2005). Further, the lack of e-Government staffing is linked with lack of financial resources. The shortage of IT skills is identified as a major constraint (Heeks, 1999; Chen and Gant 2001 and Moon 2002). There is a lack of institutional support to develop expertise and skill in e-Government. Thus many e-Government projects suffer from absence of skilled human capital (Morshed, 2007; Taifur, 2006 and BEI, 2004).

Technological capability is related with hardware, software, and expertise required for implementing projects. E-initiatives demand investments for securing hardware, software, and expertise. Bonham *et al*. (2001) and Bourn (2002) highlight technical infrastructure as a significant barrier to provide electronic services. Moreover**,** ICT infrastructure, use of ICT in developing nations are very weak and low (Bhatnagar and Bijorn-Andersen, 1990; Yong, 2003). It worsen the situation when it adds to the absence of technical infrastructure planning and sub-optimal use of available infrastructure (MOSICT, 2006 and Taifur 2006).

Legal aspects

Legal barrier includes regulatory framework, privacy, and security. A sound legal or policy guidance is essential for e-Government implementation (Lane and Buchmann, 1996; Rousseau *et al*., 1998). In the absence of legislation organisations become vulnerable to issues such as public access, privacy, system integration, security, and confidentiality (Daws, 1996; Edmiston, 2003). The current regulatory framework for e-

Government is not adequate in Bangladesh. Currently, cyber crime, electronic authentication are not protected by any laws.

Dalal (2007) views laws regarding openness are the backbone of success of e-Government. Transparency and accountability mechanisms should be strengthened in the form of legislation, regulation and policy. The World Bank suggests that anticorruption laws to be adopted to form overseeing bodies that will have the authority to investigate officials involved in corruption in governments and in the private sectors (Marquette, 2001).

Breach of privacy and security may harm public trust in e-Government. Trust is crucial which determines whether user will choose the service through Internet. Thus organisations need to be aware of the issues that they have to be trustworthy in handing all the information during the delivery of services. Kubicek (2004) cautions that in order to achieve the goal of transparency and openness the risk of breaking citizens' privacy may arise from ethical and legal perspectives. Another important aspect is the maintenance of official secrecy for the sake of so called national security and integrity. Regulatory provisions are often in place to control information flow and to maintain confidentiality.

CONCEPTUAL FRAMEWORK

Based on the discussion in the literature review section we proposed a conceptual framework to access the critical factors of the supply-side of the e-Government implementation in Bangladesh. The framework is shown in Figure 1 which is described by nine factors and three higher-level constructs.

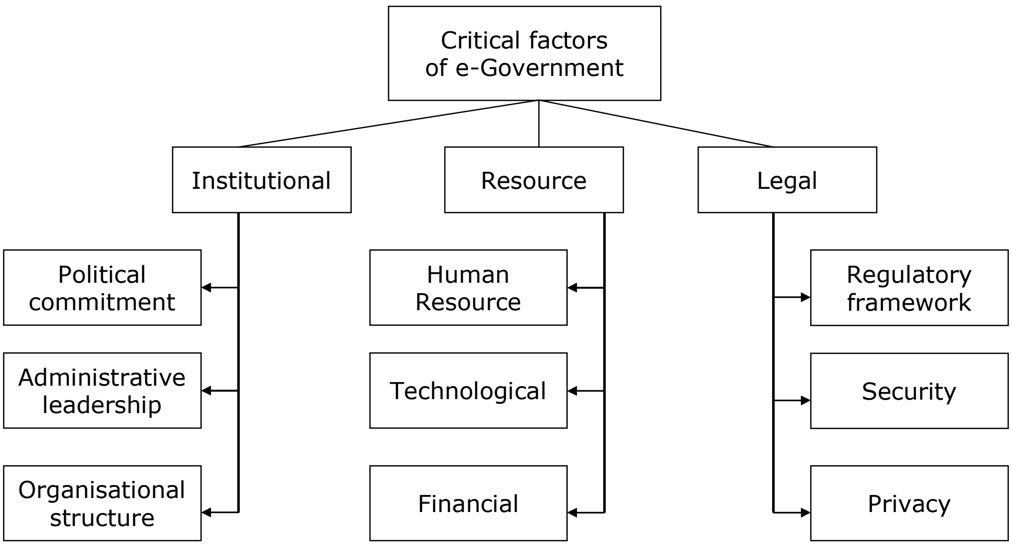

Figure1: The proposed conceptual framework

Three higher-level constructs are institutional, resource, and legal issue related. Institutional weakness can be seen as lack of political commitment, administrative leadership, and unaligned organisational structure to implement e-Government. Resource implies shortage of human resources in terms of skilled personnel, trained professional, lack of adequate and appropriate ICT systems, and lack of financial support. Legal aspect includes regulatory framework, privacy, and security concerns.

RESEARCH METHODOLOGY

Respondents

The purpose of this study is to identify critical factors of e-Government implementation. To address this objective, respondents were chosen on the basis of their capacity to generate information ensuring that research aims are met. Using a structured questionnaire a total of 24 senior officials were interviewed who worked closely with broad range of e-Government efforts of the government of Bangladesh, including the formulation of e-Government strategy, management of e-Government projects, and development of change management programs. The respondents were members of four categories of organisation such as public officials and policy makers, implementation agency, ICT task force, and development partners. The distribution of respondents is shown in Table 1. The interviews were conducted in late 2009.

Respondent category	Member	Description	Number of Respondents
Category-1	Public officials and Policy makers	Senior public officials who work closely with broad range of e-Government efforts of the government, including the formulation of e-Government strategy, management of e-Government projects, and development of change management programs	11
Category-2	Implementing agencies		6
Category-3	Member, ICT Task Force and others	Representatives from the National ICT Task Force (highest ICT policy making body of the country). They are responsible to identify and priorities ICT-related needs. Within others are the representatives from selective professional groups such as Transparency International, Bangladesh, Anti-corruption Commission	4
Category-4	Representatives, Development partners	They were the representatives from different development partners who are actively involved in e-Government implementation in Bangladesh. They belong to organisations such as UNDP, World Bank, and Asian Development Bank.	3

Table 1: Distribution of respondents

Data Analysis Method

The effectiveness of decision-making processes for complex systems depends largely on the ability to understand cause-effect relationships between variables interacting within the systems. The Decision-Making Trial and Evaluation Laboratory (DEMATEL), originated at the Battelle Memorial Institute, Geneva between 1972 and 1976, is an effective procedure for analyzing problem structure and develop causal relationships between factors or sub-systems (Fontela and Gabus, 1974). The DEMATEL methodology has been applied in many fields such as hospital service quality, sustainable development, project selection. The procedural steps of DEMATEL methodology are as follows:

Step 1: *Generate direct-relation matrix*: Suppose there are R decision-makers (experts) involved in the study and n number of decision-making factors. Each decision-maker is asked to indicate the degree to which a factor i affects factor j. These pairwise comparisons between any two factors can be denoted by x^k_{ij} and given an integer score ranging from 0, 1, 2, 3, and 4, representing 'No influence', 'Low influence', 'Medium influence', 'High influence', and 'Very high influence' respectively. The elements for $i = j$ are set to zero. Responses from each decision-maker give rise to a $n \times n$ non-negative matrix, $[x^k_{ij}] = X^k$, where k = number of decision-makers varying between *1* and *R*. An initial direct-relation matrix, a_{ij}, therefore can be expressed as;

$$a_{ij} = \frac{1}{R}\sum_{k=1}^{R} x^k{}_{ij} \qquad \text{(equation 1)}$$

Step 2: *Normalising the direct-relation matrix:* The normalized direct-relation matrix M can be obtained by the following expression:

$$M = \frac{A}{\mu} \text{ ; where } \quad \mu = \max(\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}) \quad \text{(equation 2)}$$

Step 3: *Obtaining the total-relation matrix*: Once the normalized direct-relation matrix is obtained, the total relations matrix *T* can be derived from the following expression:

$$T = M + M^2 + M^3 + ... = \sum_{i=1}^{\infty} M^i$$

$$T = M(I - M)^{-1}, \text{ where } I \text{ is an identity matrix} \qquad \text{(equation 3)}$$

Step 4: *Compute dispatcher group and receiver group*: Define *S* and *C* a *nx1* and *1xn* vectors representing the sum of rows and sum of columns of the total-relation matrix *T*, respectively. Suppose S_i be the sum of *i*th row in matrix *T*, then S_i summarises both direct and indirect effects given by factor *i* to the other factors. Similarly, suppose C_j be the sum of *j*th column in matrix *T*, then C_j summarises both direct and indirect effects given by factor j to the other factors. The expression ($S_i + C_j$) indicates the degree of importance that factor *i* plays in the entire system, whereas, ($S_i - C_j$) indicates the net effect that factor i contributes to the system. If ($S_i - C_j$) is positive, factor *i* is net dispatcher, and if ($S_i - C_j$) is negative, factor *i* is a net receiver.
Step 5: *Set threshold value and obtain the cognition map*: The cognition map can be derived by mapping the dataset of the ($S_i + C_j$) and ($S_i - C_j$), where ($S_i + C_j$) is the horizontal axis and ($S_i - C_j$) is the vertical axis. To construct an appropriate map, decision-maker must assign a threshold value for the influence level. Only some factors whose influence level in matrix *T* is higher than the threshold value will be chosen to construct the map. If the threshold value is too low, the map will be too complicated, whereas, if the threshold value is too high, many factors will remain independent without showing the relationships with other factors.

Application of the DEMATEL methodology

As discussed in the literature review section, nine factors were considered for e-government implementation. These factors are F1: Political commitment, F2: Administrative leadership, F3: Organisational structure, F4: Economic, F5: Technological, F6: Human resource (HR), F7: Regulatory, F8: Privacy, and F9: Security. A total of 24 senior officials were surveyed who worked closely with broad range of e-Government efforts of the government of Bangladesh, including the formulation of e-Government strategy, management of e-Government projects, and development of change management programs.

Analysis and Results

Using pairwise comparisons, 24 matrices based on 24 responses were generated. These were then used to obtain an average matrix using equation 1. Using equation 2, a normalized direct-relation matrix was generated. Finally, the total relation-matrix was computed using equation 3 which is shown in Table 2.

Factors	Political	Adm Lead	Org struc	Economic	Technological	HR	Regulatory	Privacy	Security
FI:Political	0.032	0.292	0.128	0.218	0.202	0.178	0.258	0.286	0.205
F2:Adm Leadership	0.097	0.034	0.302	0.137	0.284	0.288	0.357	0.340	0.369
F3:Org. structure	0.005	0.010	0.095	0.065	0.205	0.169	0.246	0.247	0.272
F4:Economic	0.081	0.085	0.153	0.053	0.292	0.259	0.144	0.200	0.286
F5:Technological	0.003	0.010	0.211	0.037	0.122	0.259	0.160	0.200	0.294
F6:HR	0.005	0.037	0.189	0.031	0.251	0.085	0.183	0.181	0.252
F7:Regulatory	0.003	0.006	0.152	0.036	0.185	0.117	0.119	0.268	0.289
F8:Privacy	0.004	0.007	0.078	0.054	0.154	0.108	0.216	0.110	0.263
F9:Security	0.009	0.015	0.218	0.114	0.305	0.216	0.293	0.315	0.209

Table 2: The total-relation matrix

The direct and indirect influence of recycling operations implementation factors are shown in Table 3. Based on (S_i + C_i) values the importance of nine factors can be prioritized as F9 > F5 > F8 > F7 > F6 > F3 > F2 > F4 > F1. The most import concerns are F9: Security and F5: Technological with values 4.153 and 3.246 respectively. However, factors such as F1:Political commitment, F2:Administrative leadership, and F4: Economic are net dispatcher and factors such as F3: Organisational structure, F5:Technological, F6: Human resource, F7:Regulatory, F8: Privacy, and F9: Security are net receivers. Given the current high level political commitment, it is important to concentrate on developing appropriate administrative leadership and acquisition of resources.

Factors	S	C	Si + Cj	Si - Cj
FI:Political	1.799	0.239	2.038	1.560
F2:Adm Leadership	2.208	0.396	2.604	1.812
F3:Org. structure	1.314	1.526	2.840	-0.212
F4:Economic	1.553	0.745	2.298	0.808
F5:Technological	1.296	1.950	3.246	-0.654
F6:HR	1.214	1.639	2.853	-0.425
F7:Regulatory	1.175	1.956	3.131	-0.781
F8:Privacy	0.994	2.147	3.141	-1.153
F9:Security	1.694	2.459	4.153	-0.765

Table 3: The degree of influence of the factors

In this study a threshold value of 0.250 was used to construct the cognition map (Figure 1).

Among the dispatchers, F1: Political commitment is the main factor. It directly impacts on F2: Administrative leadership, F4: Economic, and F7: Regulatory, and F8: Privacy. F2: Administrative leadership in turn impacts on all other factors except F4: Economic. The results indicate that there exist interactions between F7, F8, and F9.

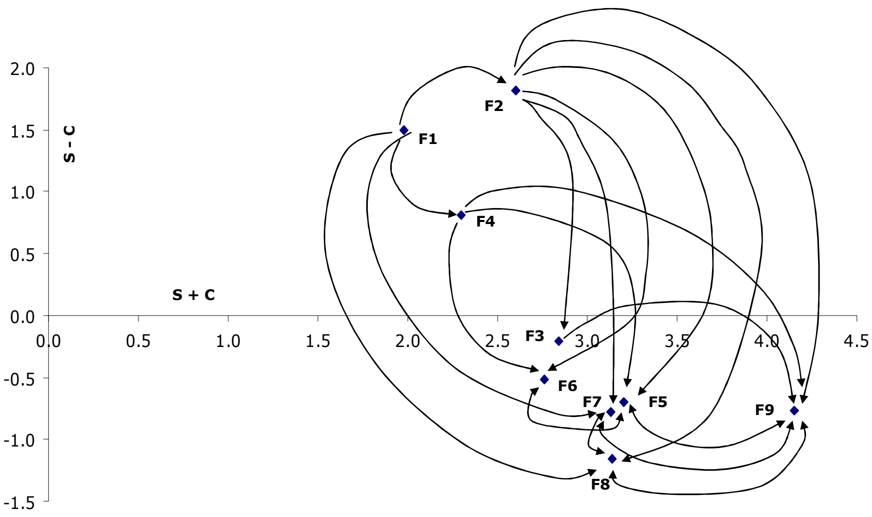

Figure 2: The cognition map of total relationship

This study provides an assessment on the factors of e-Government implementation in Bangladesh. Based on extensive literature, a framework for the supply-side e-Government implementation has been proposed with nine factors and three higher-level constructs. Data were collected against these factors using 24 respondents who belong to four categories of organisations such as government policy makers and public officials, development partners, implementing agencies, and ICT task force members. Nine factors of the proposed e-Government framework were subjected to the DEMATEL analysis. The DEMATEL methodology was employed to generate a cognition map of causal relationships of the factors.

The results indicate that from the supply perspective the major concerns for e-Government implementation are security, technological issues, and regulatory framework, whereas, the main drivers are political commitment, administrative leadership, and resources. Political leadership directly influences the administrative leadership, funding provision, development of regulatory framework, and privacy issue regarding e-Government implementation. Results also indicate that the implementation agencies must develop right organisational structure, formulate appropriate regulatory framework, and ensure security. Earlier studies in e-Government were conducted using mainly case study methodology and qualitative approach. This research is one of the rare studies which apply a quantitative approach using data from four categories of stakeholders. The findings of this study can be transferred to other developing nations.

REFERENCES

Backus, M. (2001)."E-Governance in Developing Countries", IICD Research Brief, No. 1.

BEI, (2004). "Study of e-Government in Bangladesh", Bangladesh Enterprise Institute and Asia Foundation, Dhaka, pp.56.

Bhatnagar, S.C. and Bjorn-Andersen, N. (1990). *Information Technology in Developing Countries*. Amsterdam: Elsevier Science.

Bonham, G., Seifert, J. and Thorson, S. (2001). "The transformational potential of e-government: at the role of political leadership", paper presented at 4th Pan European International Relations Conference, University of Kent.

Bourn, J. (2002). *Better Public Services Through E-Government,* The National Audit Office, London.

Caffrey, L. (1998), "Information sharing between & within governments", The International Council for Technology in Government Admin, London, A study group report of the Commonwealth Secretariat.

Chen, Y. and Gant, J. (2001). "Transforming local e-Government services: the issue of application service providers",Government Information Quarterly, 18, 4, pp.343-55.

Coursey, D., (2005). E-Government: Trends, Benefits, and Challenges. In *the Municipal Yearbook,* 14-21, Washing DC: International City/County Management Association

Coursey, D. and Norris, D. (2008). Models of e-Government: Are They Correct? An Empirical Assessment", *Public Administration Review,* 68, 3, pp.523-536.

Dalal, P. (2006). "Cyber Law Forum: Electronic Governance and Transparency", URL (accessed on 28/2/07): http://perry4law.blogspot.com/2005/06/electronic-governance-and-transparency.html

Dawes, S.S. (1996). "Interagency information sharing: expected benefits, manageable risks',*Journal of Policy Analysis and Management*, 15, 3, pp.377–394.

Dawes, S.S and Pardo,T. (2002). "Building collaborative digital government systems", in Mclver, W. J. and Elmagarmid, A. K. (Eds): Advances in Digital Government Technology,

Edmiston, K.D. (2003). "State and local e-government: prospects and challenges", *American Review of Public Administration*, 33, 1, pp.20-45.

Heeks, R. (Ed.) (1999). *Reinventing Government in the Information Age: International Practice in IT-enabled in Public Sector Reform,* Routledge, London.

Kettl, D.F. (2002). *The Transformation of Governance*, *Public Administration for Twenty-First Century America,* John Hopkins University Press, U.S.A.

Koh C. E., Ryan. S. and Prybutok, V. R. (2005). “Creating Value through Managing Knowledge in an E-Government to Constituency”, *The Journal of Computer Information Systems, 45, 4.*
Kubicek, H. (2004). Third-generation freedom of information in the context of egovernment: The case of Bremen, Germany. In G. Aichholzer & H. Burkert (Eds.), *Public Sector Information in the Digital Age: Between Markets, Public Management and Citizens' Rights.* Edward Elgar Publishing Limited, Cheltenham.
Lam, W. (2005). “Barriers to e-government”, *Journal of Enterprise Information Management,* 18, 5, pp.511-530.
Lane, C., and Buchanan, R. (eds) (1998). *Trust Within and Between Organisation: Conceptual Issues and Empirical Applications, Oxford University Press, Oxford, UK.*
Mahmood, R. (2004). “Can Information and Communication Technology Help Reduce Corruption? How So and Why Not: Two Case Studies from South Asia.” *Perspectives on Global Development and Technology* 3, 3, pp. 347-373.
Marquette, H. (2001). Corruption, Democracy and the World Bank. *Crime, Law & Social Change,* 36, pp.395-407.
Moon, M.J. (2002). “The evolution of e-government among municipalities rhetoric or reality”, *Public Administration Review,* 62, 4, pp.424-33.
MOSICT (Ministry of Science and ICT). 2006. E-governance activities. Retrieved June, 2006, from http://www.mosict.gov.bd/what_new.htm
Morshed, K. (2006). E-Governance: Bangladesh Perspective, Bangladesh ICT Policy Monitor Network, URL (consulted March 11, 2007): http//Bangladesh ictpolicy. bytesforall.net
NECCC (2000). *E-Government Strategic Planning,* National Electronic Commerce Coordinating Council, Las Vegas, NV.
Ndou, V. (2004). “E-Government for Developing Countries: Opportunities and Challenges,” *Electronic Journal of Information Systems in Developing Countries,* 18, 1, pp.1-24.
Norris, F., Fletcher, P.D. and Holden, S.H.(2001). *Is your local government plugged in? Highlights of the 2000 Electronic Government Survey,* University of Maryland, Baltimore, MD.
OECD(2003). *The E-Government Imperative* http://www1.worldbank.org /public sector/egov /E-GovernmentImperative.pdf.
Rousseau, D.M., Sitkin, S.B., Burt, R.S., Camerer, C. (1998), "Not so different after all: a cross discipline view of trust", *Academy of Management Review*, 23, 3, pp.393-404.
Schware, R. and Deane, A. (2003). “Deploying e-Government Programs: The Strategic Importance of 'I' before 'E'”, *Info – The Journal of Policy, Regulation and Strategy for Telecommunications,* 5, 4, pp.10-19.
Singh, S.H. (2003).”Government in the Digital Era and Human Factors in e-Governance”, A paper presented at Regional Workshop on e-Government.
Taifur, SASM. (2006). *SICT's Steps Towards Good Governance through ICTs - e-Governance Strategies*, Ministry of Planning, Bangladesh.
Yigitcanlar, T., Baum, S. and Stimson, R. (2003). “Bridging the Gap Between Citizens and Local Authorities via E-government”, Symposium on E-government: Opportunities & Challenges, Muscat – Sultanate of Oman.
Yong, JSL. (2003). *E-government in Asia: Enabling Public Service Innovation in the 21st Century*, Times Media, Singapore.

EURIDICE
PLATFORM ARCHITECTURE FOR PRO-ACTIVE AND AUTONOMOUS LOGISTICS OPERATIONS

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ABSTRACT
EURIDICE is an EU funded project which deals with the development and implementation of new concepts in the area of intelligent cargo. The goal of EURIDICE is to develop a free and open standards based platform for intelligent goods, by using distributed mobile systems. This paper will provide an overview about the architecture and key technologies.

THE EURIDICE PROJECT
As a result of the EU-FP7 funded research project EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics - FP7-ICT-2007-216271) the project's consortium recently published the EURIDICE reference architecture for an open, extendable and interoperable platform for advanced information services for freight transportation under the concepts of intelligent cargo. The project mainly deals with the research on autonomous business processes for logistics and supply chain management. The concepts of intelligent cargo intend to trigger a paradigmatic change in the field of ICT applications for transport logistics. In the EURIDICE vision, Intelligent Cargo connects itself to logistics service providers, industrial users and authorities to exchange transport-related information and to perform or trigger specific services whenever required along the transport chain. This will produce significant benefits for the logistics industry and for the community.

The fundamental question that is related to these issues is whether it is worthwhile to retain to structured processes or whether it would be better to define a new self-controlled process regarding future logistics operations. The European project EURIDICE opted for the later approach. The project is based on the assumption that in the future the usage of passive and active RFID chips will increase and as such the availability of intelligent mobile devices will likewise also increase. This will lead to a situation where more and more local intelligence is available and thus also the capability to process information locally and take local decisions on the basis of this information – which is the fundamental idea behind the concept of the *intelligent cargo*. EURIDICE predicts a future where the computing capabilities will be increasingly decentralized, and thus will lead to a situation where the distributed computing capabilities will be used on the spot to make local decisions within the local environment and current context, rather than taking the typical client server approach of today's services infrastructures into account.

THE EURIDICE ARCHITECTURE
The core design of the platform is based on available standards like SOA (Service Orientated Architecture) and Multi-Agent-Systems (MAS) for realization of the cargo-centric-approach. This core is enhanced with implemented services derived from extensive requirements analysis at different stakeholders in logistics chains, e.g. logistics service providers, infrastructure providers, ports and authorities and production companies. The EURIDICE architecture maintains a set of cargo-centric services which can be consumed independently (Figure 1). From a user's point of view these services encapsulate a single cargo item. Cargo-centric services range from typical tracking &

tracing services to more sophisticated business related services like quality assurance, handling of customs or certification of cool-chains. To satisfy most different scenarios the cargo-centric services can be combined on the fly.

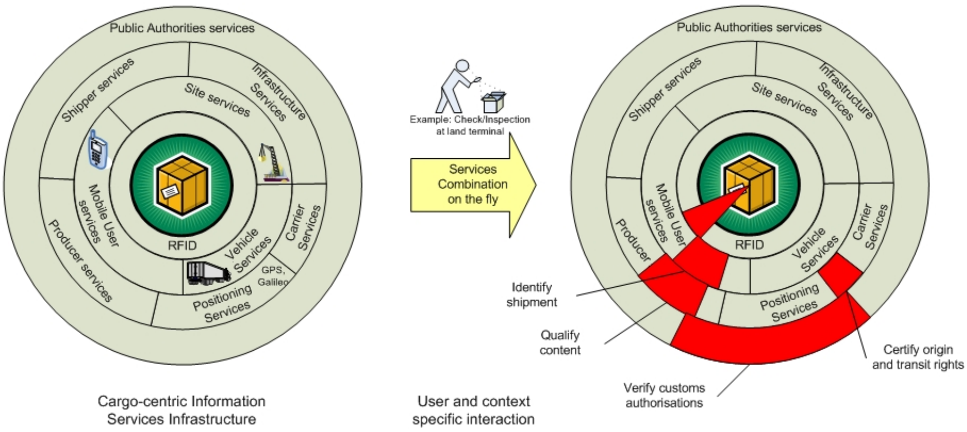

Figure 1 Cargo-centric information services infrastructure

The Service Oriented Perspective

Conceptually the platform consists of services at different levels and scopes. Roughly these services can be categorized as shown in Figure 2. The EURIDICE specific services (CS) are common, enclosed and reusable small processes to allow an easy composition of applications specific services for the definition and orchestration of business processes on top of them. These application specific services or business processes can also be used by other application specific services and processes. On the lower levels of the framework, the generic components level, EURIDICE provides generic services for internal use within the framework. Those services are mainly used from inside the platform and consist of low-level operations like reliable communication among the distributed platform, the management of certain sensors, event handling or context detection.

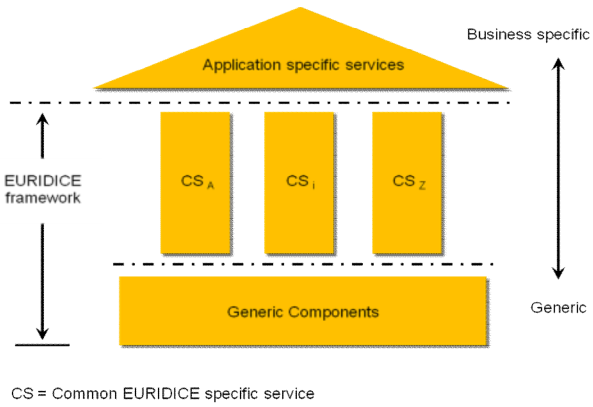

Figure 2: General levels and scopes of EURIDICE services

The service oriented perspective of the platform as introduced above gives a good overview of the general characteristics of the system from the integration point of view. Standard technologies like SOA, Enterprise Service Bus and Business Process Modelling technologies like BPEL (Business Process Execution Language) or BPML (Business Process Modeling Language) provide well known interfaces for business process modelers and ensure an open and flexible platform from the top-level perspective.

The Architectural Components Perspective
From a components point of view the EURIDICE platform is divided into two main components. Based on different responsibilities and scopes the platform is split into a fixed and a mobile part (Figure 3). Basically the fixed part offers an interface for external systems and end-users. It allows the integration of user defined business processes. As mentioned in the introduction of this paper, the EURIDICE system lifts single cargo items into a top-position within the business processes. Enriching the capabilities and the responsibilities of cargo items not only on a conceptual level, can be reached by equipping them with computation capabilities and integrating those parts into the business processes, which means not to just use them as a source of information, but additionally promoting them to the central part of the system. Therefore cargo-related processes are directly driven by the concerned cargo items (mobile part).

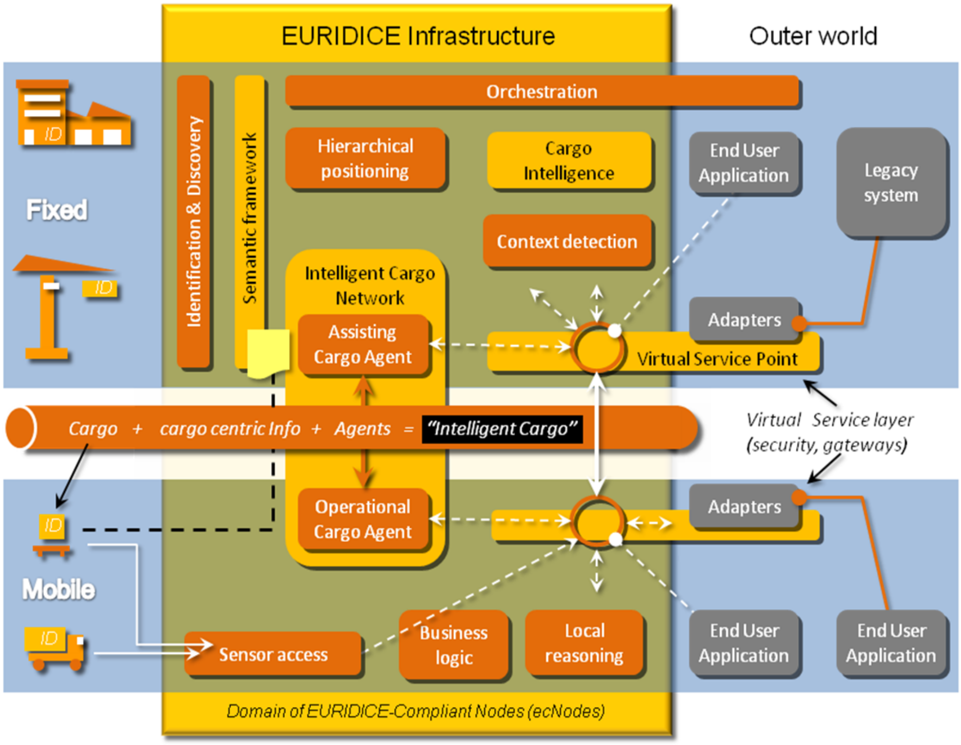

Figure 3 Detailled components of the EURIDICE platform

ecNodes
The abstract concept of an ecNode (EURIDICE Compliant Node - pronunciation "easy node") is used for the reduction of complexity in representation for all business objects (e.g. cargo, means of transportation, services and even human operators). An ecNode has a unique identifier and additionally has a reference to an information provider, providing additional information when authorized. Therefore global identification and discovery services, as described in the concepts of SOA, are included in the architecture for information retrieval based on an ecNode identifier.

Intelligent Cargo Network
The Intelligent Cargo Network is formed by identified cargo objects. It forms a bridge between the centralized and distributed parts of EURIDICE. It offers and defines the concept of intelligent cargo as the combination of cargo, a cargo centric approach to deal with related information and the use of associated Cargo Agents to assist in the exchange of cargo related information. It is implemented as a Multi Agent System and mainly consists of the following parts:

The Assisting Cargo Agent (ACA) is a special kind of information provider within the Intelligent Cargo Network. It is introduced and used as a single point of access for the exchange of information about cargo, and acts like a virtual representation for an intelligent cargo item that supports information access. The references to cargo information are collected in an electronic cargo document, maintained by the Assisting Cargo Agent. The Assisting Cargo Agent represents only a purely virtually representation of the cargo, while the Operational Cargo Agent (OCA) assists the cargo item in the physical world by collecting and distributing information. The Operational Cargo Agent also includes local intelligence and can use it to:

- take proactive initiatives related to real-time information,
- provide information to interested parties
- make suggestions for measurements to take
- cooperation with other nearby intelligent cargo items, by sharing measurements for instance, as well as with the back-office
-

As implementation costs are still an issue, especially with low value goods, the functionalities can be delegated to a nearby mobile ecNode, e.g. container or onboard unit of a truck or train.

Virtual Service Point
This represents in the developed architecture a component regarding security issues. Information and services can be only accessed by a Virtual Service Point, enforcing security restrictions and providing secure communication services, to support the usage of one common platform between business entities and allows secure communication in a peer-to-peer like network. The Virtual Service Point routes authorized information and also requests for information to the required services. In this part of the EURIDICE architecture additionally also services will be hosted and implemented to allow the usage of specific end-user-applications and integration with legacy systems.

Semantic Framework
For cooperation across organizations and business domains, a semantic framework, based on common data models and ontologies [1], reduces the barriers for adoption and communication between business entities. Therefore a semantic framework has been developed to support the usage and adoption of the core services of the platform, but additionally also business specific services, based on business related data models elaborated with the pilots in the project, supporting the development of end-user-applications and integration with legacy systems

Context Detection
For providing the ability of interaction between cargo objects and systems regarding the environment of a cargo item, a common ontology and necessary data models are developed as part of the semantic framework, to enable services to detect and relate to the current context of cargo items. This provides a common understanding between EURIDICE services in the context of the cargo item, and additionally by usage of sensor measurements, simple "tracking & tracing" information can be enriched with additional dynamic accessible information related to the current cargo context, as well as the interacting entities, e.g. freight forwarders, authorities and logistics services providers.

Cargo Intelligence
EURIDICE promotes as one of its key solutions the already mentioned Intelligent Cargo (IC) concept supported by global reasoning. Therefore a standardized knowledge structure (provided by an ontology) extended by rules, relations and actual measurements, trends and unusual deviations being determined are shared by the participating entities in the platform. This knowledge structure cannot be only used for centralized decision-making, but also for decision-making in the field, at the intelligent

cargo itself for assisting other entities, e.g. human operators, in the decision-making process.

Orchestration
Orchestration relates to the same concept of a SOA, providing mechanisms for orchestration of services across business domains and to facilitate cooperation between stakeholders in the supply chain. This enables the combination of different services provided by participants in supply chains and users of the platform. Therefore highly specialized applications can be implemented based on single services or also by usage of sub processes.

INTELLIGENT DEVICES
As physical and virtual parts of the EURIDICE platform are distributed to different components of the logistics infrastructure, different stocks, warehouses, vehicles, containers, single cargo items and additionally for the handling of the virtual processes, such a federative system (or such parts of a system) requires choosing of an architecture considering the limitations and challenges of a mobile computing system. [2]
Within EURIDICE, single cargo items, containers, vehicles and other entities of the logistics domain are equipped with mobile devices in order to host the distributed part of the platform. Mobile devices work with limited resources. They have a limited power supply, limited CPU processing power and storage space. In most cases they do not guarantee a quality of service concerning the wireless connections and there are many more restrictions which have to be considered when developing mobile applications.

Therefore the platform implies more or less sophisticated devices (depending on the mission to fulfill) installed at single cargo items where in the best case the architecture can use the Multi-Agent approach with all its benefits. An intelligent, mobile agent is a piece of software that acts on the behalf of someone else, in our case on the behalf of a single cargo item where it represents its interests and goals. Agents work autonomously with absence of any user interaction. Their lifecycle is strongly coupled to the lifecycle of their representative. Agents work continuously and autonomously in a particular environment. [3] They communicate and corporate with each other, with other processes and their environment (e.g.: via sensors) which makes them in some way intelligent and context aware. Agents usually act dynamically; they adapt their behavior based on the context they reside. The mobility of an agent does not only indicate that the devices hosting the software can be moved physically, it says that the agent itself is strongly decoupled from the hardware it runs on. Mobile agents are able to dynamically move from one machine to another. This approach is called 'migration' of an agent. [4] Such systems are able to be physically present almost anywhere and anytime which clearly seems to be very appropriate in the field of logistics where moving goods physically, from one location to another can be seen as the core competence of this business. Being physically present does not offer a lot of advantages on the first sight, but in a case where the need of real-time information, including environmental data measured by sensors (e.g. temperature via temperature sensor, position via GPS-sensor, availability of specific cargo-items in a container measured via RFID…) being physically present reduces communication problems, overhead, and time delays. The capabilities of the agents are offered as services and are the foundation for providing cargo-centric information services, observing the cargo and enabling an intelligent behavior for single cargo items.
Typical tasks performed by intelligent cargo agents could be tracking and tracing of goods, anomaly detection concerning the environment of the cargo in the meaning of critical temperatures, g-forces or humidity levels, but also wrong traveling directions, delays or early arrivals. The local computation approach minimizes the use of centralized systems to organize and redistribute the data.

By sensing the environment, the mobile and intelligent agents can react on changes or events appropriately by initiating counteractions or alarming a monitoring unit. An agent has the ability of adaption, as already mentioned, which means they are able to adapt their strategies to react on changes inside of the agent network and the environment by learning from their experiences.

Seamless integration of cargo items

We already discussed the integration of cargo items into the EURIDICE platform with the usage of mobile, intelligent agents hosted on devices installed directly at the cargo. But this approach is not feasible for all scenarios appearing in the logistics sector. There are cases where the hardware costs for hosting agents would exceed the transportation costs for a huge amount of cheap goods by far. Therefore only offering the integration of transported goods via the discussed approach does not seem to be sufficient to provide a pan-European platform for logistics services providers. For such cases the latest years have shown that RFID (Radio Frequency Identification) provides a cheap way to integrate physical items into software systems using the principles of the 'internet of things'-paradigm. The mentioned approach strongly couples real world objects to the objects representing them in the virtual world. Today neither passive nor active RFID tags provide the capabilities to host such complex software components like mobile, intelligent agents. RFID tags usually show a passive behavior. With the help of RFID readers they can be activated which means to access and read the information they provide. This information can limit itself to simple identification purposes, but with semi-active RFID tags also more complex capabilities like measuring of temperature can be realized.
The EURIDICE architecture also offers a way to integrate cargo items only equipped with less sophisticated devices like RFID tags. From a higher level point of view, such cargo items show exactly the same behavior as items equipped with complex, more sophisticated devices. That means that basically all the services offered by EURIDICE-enabled cargo items are also available for RFID tagged items. To realize this transparent integration of different types of cargo, the architecture introduces the already mentioned concept of the Assisting Cargo Agent (ACA).

Assisting Cargo Agent – Operational Cargo Agent

Within EURIDICE a single cargo item is represented by a software agent [5] as already introduced in the section above. Cargo agents installed on devices in the field are called Operational Cargo Agent (OCA). Operational cargo agents always own a centralized counterpart – the assisting cargo agent. The assisting cargo agent – as its name already says – assists the operational one. It is deployed centrally within the EURIDICE centralized framework. Conceptually there is a one to one relation between an operational cargo agent and an assisting one. The assisting cargo agent shows the same interface and behavior as its operational counterpart. It is used for different purposes:

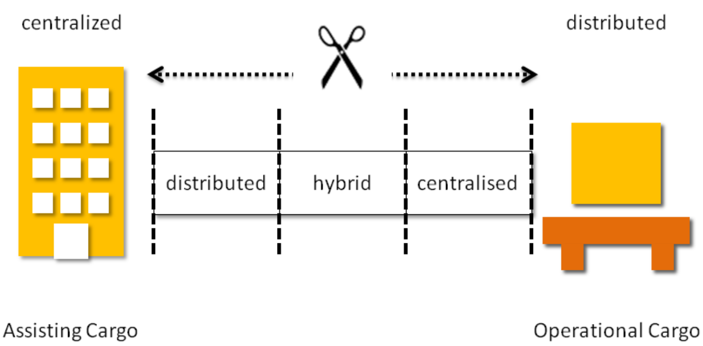

Figure 4: Functionality of Assisting and Operational Cargo

If one thinks of a band containing all functionality concerning a cargo item (Figure 4), one can cut it into two pieces, where the left side of the band is hosted centrally and

managed by the assisting cargo agent, and the right side is hosted remotely on mobile devices, handled by the operational one.
Depending on the type of device used for the operational cargo agent, the level of distribution respectively centralism can be configured. Cutting between point (1) and (2) would result in a very distributed approach where most of the functionality is hosted remotely by the operational cargo agent. Cutting between (3) and (4) shows the opposite behavior where a very small part of the functionality is offered by the operational cargo agent itself.

Services that cannot be hosted remotely are covered centrally by the assisting cargo agent. Obviously this is not always possible or will lead to a bad quality of information. Observing the temperature of some cargo cannot be done centrally. For that purpose again the cooperation of agents can be used to solve such problems. Assisting cargo agents can delegate tasks to other cargo items – namely to other assisting cargo agents. They forward the tasks to their operational counter parts. That means that assisting cargo agents are able to cooperate with operational cargo agents from other cargo items which are in proximity of its own cargo. This opens the opportunity to also have high quality information gathered remotely for cargo that is only poorly equipped.

PILOT CASES

Within the EURIDICE project the developed concepts are evaluated against real-life business cases. One of the test-cases is hosted by the logistics provider Gebrüder Weiss. Gebrüder Weiss is one of the biggest logistics providers in Austria.

The purpose of this business scenario is to test a continuous, intelligent and distributed cargo monitoring. This means to observe some cargo on its journey and to observe several issues to initiate proper business-events:

- **Track and trace the cargo** (global positioning)
  The position of the cargo can be tracked at item level. So not only the position of the vehicle itself is of general interest, but also the position of each single item. According to events like the arrival at a certain region, or the departure from a certain warehouse (which both can be recognized with the help of the cargo's position) trigger and press ahead dedicated business processes.
- **Observe the environment of the cargo** (temperature, eruption, light, ...)
  Due to legislative regulations a logistics provider needs to satisfactory show that the cargo met all the environmental restrictions (temperature, light, ...) during its whole delivery process.
- **Observe the business-relevant states of the cargo**
  It is mandatory for business process optimization to always be informed about the
  state of the cargo handled by a logistics provider. Business-States could be: "*in store*", "*packaging*", "*shipping*", "*delayed*" ...

One of the main characteristics of the *intelligent and distributed cargo monitoring* is that the information gathered by the system is available in **real-time**. This information can be included into existing IT-Systems used by the logistics provider. Furthermore other pilot cases dealing with for example customs clearance or route forecast of arrival times are implemented within the project to properly evaluate the EURIDICE system in different scenarios.

CONCLUSION

This paper shows how different concepts (SOA, Multi-Agent-Systems, Reasoning, Semantic Reasoning) can be tailored to a uniform, transparent and open system. The EURIDICE Architecture aims to exploit all the advantages of these different technologies to properly handle the enormous requirements regarding openness, robustness, scalability and maintainability.

The EURIDICE architecture especially takes the interoperability and the role of standards into account to properly serve the diverse field of European logistics. The architecture proposes mechanisms to support different legacy systems used by logistics operators all over Europe, as well as standardized data structures implemented as a semantic framework based on a well suited ontology to offer a common understanding and the basics for advanced techniques for applied reasoning and data analysis on the information gathered and managed by EURIDICE.

The EURIDICE project deals with the logistics domain, namely the transportation sector within Europe. The platform presented in this paper mainly enables the concepts of *intelligent cargo items* and fills the gap between pro-active, autonomous cargo items and higher-level business services applied by enterprises. Future research in this field should elaborate on the applicability of the concepts of *intelligent cargo* for other domains apart from the transportation sector, like the manufacturing, maintenance or product lifecycle management.

REFERENCES

[1] D. Fensel. **Ontologies: Silver Bullet for Knowledge Management and Electronic Commerce**, Berlin: Springer, 2001.

[2] A. Greenfield, **Everyware – The dawning age of ubiquitous computing**, Berkeley: New Riders Publishing, 2006.

[3] K. P. Sycara, **Multiagent systems.** AI Magazine, 19(2), 1998.

[4] P. Braun & W. Rossak, Mobile Agents: Basic Concepts, Mobility Models, and the Tracy Toolkit. San Francisco: Morgan Kaufmann, 2004.

[5] J. M. Bradshaw, **Software Agents**, Cambridge: The MIT Press, 1997.

INTERNATIONAL LOGISTICS AND THE SINGLE WINDOW CONCEPT

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ABSTRACT

This paper provides a review of the "Single Window" concepts (UN/CEFACT 2004) and related electronic infrastructure for the sharing of trade related data between business and government stakeholders in international logistics operations. As such, the paper outlines key principles, operational requirements and the wider policy context. Much of the current policy momentum towards developing single window type infrastructure can be associated with commitments made by governments – for example at the WTO (2009) or within ASEAN (2005) or the EU (TAXUD/477/2004) – towards enhancing trade competitiveness. However, the single window concept is also of equal relevance to reform initiatives driven by supply chain security considerations (e.g. WCO 2007). The research presented in this paper builds on a technical note produced by the author for the World Bank. The paper's aim is to expand on the current literature (e.g. Applegate, Neo et al. 1995; Teo, Tan et al. 1997; Wulf 2004; Linington 2005), provide a taxonomy for public electronic infrastructure in cross-border operations, outline associated border management reform challenges as well as map out possible paths for their resolution.

Context (short Introduction)

The management of information flow is a key activity within logistics and is the trigger for any physical movements of goods. Specific in the context of international trade, relevant information includes purchasing orders, commercial invoices, packing instructions, shipping instructions, contracts of carriage, payment and instructions, insurance arrangements, handling requirements, amongst many others. An often forgotten aspect of international logistics operations is the effort involved in sharing and declaring information to governing government agencies, especially at the ports and borders. For example, a UN study referred to by OECD (2001) reports that over 200 data elements are typically requested in a trade transaction, of which 60-70% are re-keyed at least once while 15% are re-typed up to 30 times. SITPRO, in an unpublished study, found that the export of milk powder from the UK to a North African country can easily involve as many as 29 different parties and requires 21 different regulatory declarations, official certificates and transport and insurance documents, often with multiple copies in different languages (for an illustration see Clark 2003). A similar example of complexity, was also found by Andrew Grainger (Grainger 2009) in his case-study focusing on the trade in beef and poultry from Mercosur into the EU.

The compliance burden associated with international trade operations is often described as unnecessarily costly (e.g. OECD 2001; 2003). Costs may be direct – that is the costs of preparing and submitting trade related information to relevant authorities – or indirect – such as missed business opportunities or diminished competitiveness. The topic of trade facilitation seeks to reduce these costs. The single window concept as described in UN CEFACT Recommendation 33 (UN/CEFACT 2004) is one trade facilitation idea that has gained considerable momentum in addressing the challenges associated with sharing information between businesses and government executive agencies in international trade operations, especially within ASEAN (2005), the European Union

[1] This paper builds on earlier work produced by the author for the World Bank and as domain expert for the UK's International Trade Single Window project. The views and opinions expressed in this paper are the author's own. He can be contacted by e-mail at andrew.grainger@nottingham.ac.uk

(TAXUD/477/2004), as well as wider WTO (2009) negotiations. The single window may be described as a facility that allows all parties involved in trade and transport operations to lodge standardised information and documents with a single entry point to fulfil all import, export and transit related-related regulatory requirements. As such it radically streamlines the interface between business and government stakeholders, yielding extensive operational benefits, efficiency gains and cost-savings (UN/CEFACT 2004). One of the pioneering countries is Singapore. It links multiple parties involved in external trade transactions, including 35 government institutions, to a single point of transaction for most trade documentation tasks.

Trade Procedures and The Cross-border environment

The catalogue of possible trade and customs procedures applicable to goods or the people and vehicles that move the goods can be quite extensive. For example, Andrew Grainger (2007), in his conservative analysis of the UK trade environment counts more than 60 distinct trade procedure. Procedures may be specific to revenue collection (such as the payment of customs duties), safety and security (such smuggling controls, immigration checks or specific collaborative security programmes), environment and health (such as phytosanitary, veterinary and hygiene controls), consumer protection (such as compliance with product standards or labelling conventions), and trade policy (such as quantitative restrictions and anti-dumping measures). Practitioner observations suggest that the actual number of potential submissions of information to government agencies (Figure 1) is considerably larger, especially as most declarations have multiple components, which are often accumulative. For example an application for an authorisation or an advance notification may precede the full declaration, often containing similar or identical data.

Figure 1: Types of Trade Data Submissions to Government Agencies

- **Applications:** These tend to be a requirement where traders seek special treatment such as preferential duty rates or wish to draw on quantitative quotas.
- **Authorisations**: These are often required in order for operators to take advantage of simplified customs procedure or handle goods while under customs control. For example, most ports handling goods for international trade will have a customs authorisation allowing them to do so. Authorisation may also be required for handling goods that are normally prohibited or restricted.
- **Advance notifications and pre-notifications:** These tend to be consignment specific and enable authorities to make arrangements prior to the arrival of the goods – for example to inspect goods and ensure that sufficient staff is on standby.
- **Summary or partial declarations and supplementary declarations:** A range of simplified customs procedures allow for goods to be cleared through the port with partial declaration to customs on the understanding that a supplementary declaration, with all missing details, is provided at a later point in time.
- **Full declarations:** Here, all the information necessary to discharge the conditions laid upon the import or export of goods are provided.

Source: (Grainger 2009)

The potential number of stakeholders in cross-border operations is equally large. They include contracting traders (exporters and importers), a vast array of intermediaries (such as freight forwarders, logistics service providers and shipping lines) as well as the operators of transport infrastructure (such as port operators and stevedores).

On the regulatory side of trade operations, customs is often the most visible executive agency, but there are many others, too (Figure 2). Each of the parties involved tends to have a different picture of trade operations. For example, an exporter may know what they have sold, a freight forwarder may know in what container the goods are shipped, the shipping line might know on what vessel it is sailing, the customs broker may know about the consignment specific import details, the end customer may know when the goods have been received and whether the order had been correctly fulfilled.

Figure 2 Stakeholders in the Cross-Border Trade Environment

Traders

Small, large, importers, exports, experienced, in-experienced, agents (direct or indirect representatives)

Intermediaries

Transport and related services: Shipping Lines, Non Vessel Owning Common Carrier (NVOCC), Airlines, Charter Operators, Trucking and Haulage Companies, Railway Companies, Logistics Service Providers, Freight Forwarders, Customs Brokers, Banks and Finance Companies, Insurance Companies

Facilities and infrastructure: Seaports, Airports, Rail-terminals, Inland Container Ports, Port Operators and Stevedores, Cargo Handlers and Handling Agents, Warehouse Operators, Transit-shed Operators, IT Service Providers

Government

Revenue and Customs; Transport Ministry; Port Health Authorities; Ministry for Food and Agriculture; Marketing Boards; Trading Standards Bodies; Ministry for Trade and Industry; Civil Aviation Authority; Health and Safety Executive; Immigration Services; Finance Ministry; Ministry for Internal Affairs; Quarantine Inspection Service; Phytosanitary Inspection Services; Police; Highway Agency; 3rd Country Representatives; Contracted inspection and testing companies

Source: Grainger 2010

The coordination of relevant information amongst operators as well as with government executive agencies is a considerable operational challenge. Normally the ownership of responsibility for specific tasks is negotiated amongst contracting parties by reference to the Incoterms (ICC 1999). However, given the range of intermediaries involved in any trade transaction (e.g. agents, transport operators, handling agents, etc.), the volume of data with regulatory dependencies quickly escalates beyond the importer's and exporter's domain.

For example, while the importer (or his agent) is responsible for the full customs declaration, in many countries pre-notification or advance notification to relevant authorities is provided by the shipping line. The shipping line in turn may collate the data in advance when taking the booking from the shipper or the shipper's agent.

However, given the overall complexity of commercial arrangements, the number of agent's involved, and frequent changes to shipping schedules, the scope for getting it wrong is vast. As any seasoned customs broker or freight forwarder will attest, the statement that "goods are stuck in customs" usually means that information required for clearance is missing, inaccurate or incomplete (– as opposed to customs taking a look).

The single window solution

One of the easiest ways to set-out the case for developing a single window environment is to graphically describe the complexity of data sharing arrangements in order to clear goods at the border. As Figure 3 mischievously illustrates, it quickly resembles a child's crayon drawing. In contrast, if all information were to be captured via one central hub – the single window – a considerable degree of rationalisation can be achieved (Figure 4)

Figure 3:

The Non-Single Window: "A Child's Crayon Drawing

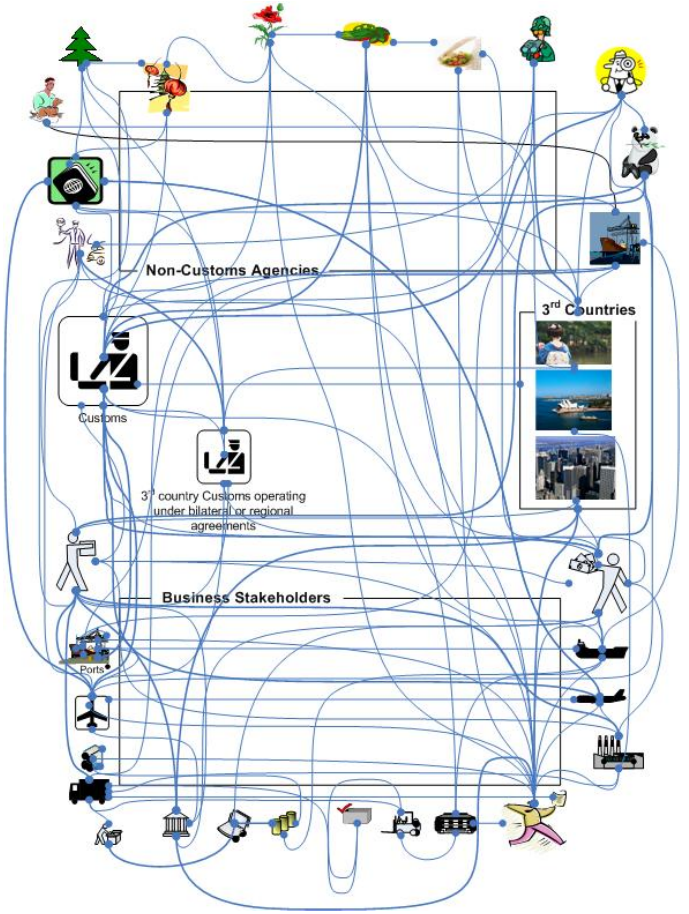
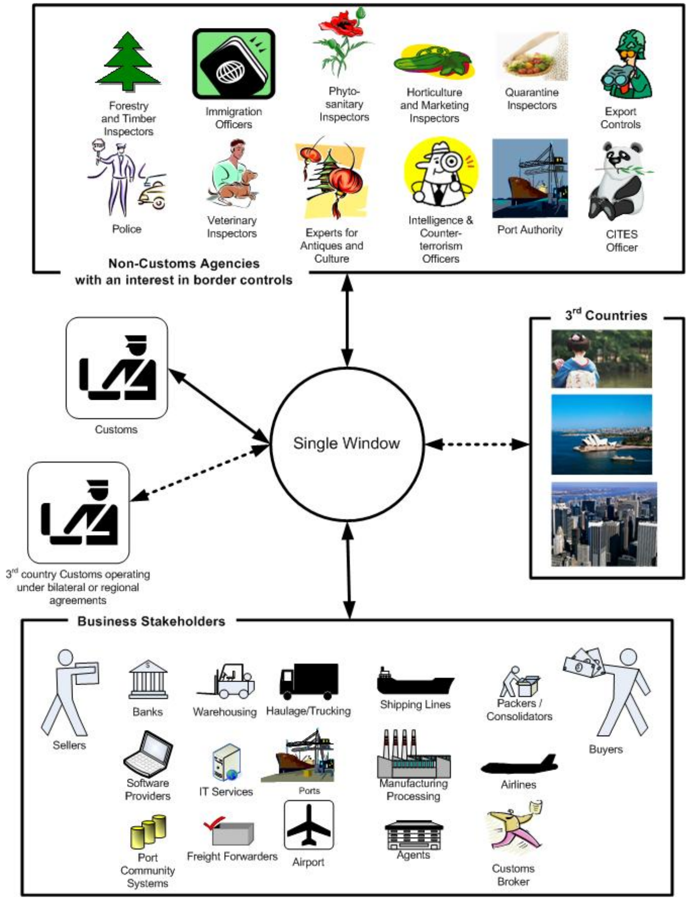


Figure 4:

The Single Window Concept



Of course the challenge of managing information flow between the various business actors and government agencies is not a new problem. Certainly with the advent of containerisation it became quickly apparent that the exchange of information would need to be enabled at speeds comparable to the revolutionised handling capabilities. At many container ports operators and port users developed community systems to share information electronically with each other as well as verify with customs whether goods have been cleared for loading or exit.

Similarly, customs administrations, faced by ever growing volumes of trade and the emergence of a global production structure needed to develop systems capable to process ever increasing volumes of trade. Electronic solutions were developed and implemented in response to the challenge. Electronic customs systems are now common place in most developed as well as many of the emerging and developing economies, especially those with export led growth strategies. Often electronic customs clearance is possible within a matter of seconds. However, where paper dependencies still exist, such efficiencies are quickly lost. Similarly, efficiency is also quickly lost where existing electronic systems are not fully interoperable. For example, in the air environment one of the first operational steps at touch-down is for the handling agent to collect the aircraft's document bag and enter the data contained within into the airport's community system before any further handling operations can commence.

In contrast, the single window concept provides an integrated infrastructure where data is captured once, significantly reducing the volume of re-keying and handling as well as scope for error. Unlike port community systems, the single window concept is not necessarily location specific[2]. It also provides a facility enabling traders to submit all trade related information to the relevant government agencies via on single interface, rather than the multitude of interfaces prevalent in the "child's crayon drawing" scenario. Ideally, it allows data once captured to be recycled and shared. For example, data initially captured in an application or authorisation could be reused for when making the full declaration. Similarly, data captured in a shipping line's berthing application to the port could be reused to confirm the vessel details in the declaration between the port and customs. Advanced shipping manifests received by the port for inventory purposes could also be reused by customs for advance screening. A ports berthing confirmation could be used as the trigger to automatically submit customs declarations that have been pre-lodged by importing traders. An import authorisation, issued by the trade ministry for a tariff quota, could be automatically attached to the customs declaration without any further actions by any of the parties concerned.

As most trade facilitation practitioners will assert, there are a range of single window models that could potentially (or already) provide the above functionality. Amongst the more authoritative models are those defined by UN/CEFACT in its Recommendations 33 (UN/CEFACT 2004). Without wishing to go into too much detail, they all broadly resemble the depiction outlined in Figure 4, though governance and systems architecture may vary somewhat. However, there are also a wide rang of related ideas and concepts, which confusingly (and mistakenly) are touted by some policy makers and systems vendors as a "single window", too. To help give some clarification, Figure 5 provides a taxonomy of single window concepts within the spirit of UN Recommendation 33 as well as list the range of the related concepts.

Figure 5. A Taxonomy of Single Window models

[2] Though, as outlined in Figure 5, port community systems are often (mistakenly) touted as single window solutions.

Single Window models in the spirit of UN Recommendation 33	
• Single Authority	One authority (usually customs) takes on the responsibility to collect all information (paper or electronic) required for processing
• Single Automated Systems - Integrated	Data is processed through the single window system
• Single Automated Systems - interfaced	Data is sent to the agencies for processing
• Automated Information Transaction System	A single facility that enables the submission of an electronic declaration to the various authorities for processing and approval in one single application
Related models and concepts that resemble or include reference to the Single Window	
• Port Community System	These are localised or 'mini single window' systems that focus on port operations and port clearance. Trade related information required prior or subsequent to clearance will usually take separate transmission channels
• Electronic Trade Platform	Primary focus is on the exchange of commercial information between contracting traders, using a shared communication platform. Functionality can include direct interfaces with government departments (e.g. uTradeHub) or electronic document generating capabilities (e.g. Bolero.net)
• Electronic and Paper Document Solutions	Commercial software products that are able to automatically create sets of documents (in paper or electronic format) as required by a trader for a particular transaction.
• Electronic Customs Systems	Systems that enable customs administration to process customs declarations electronically, normally conferring significant efficiency gains as well the ability to apply risk based controls. Electronic customs systems can also help customs authorities interface with other systems – like port community systems or a single window.
• Electronic Access Point	Facilities (usually web-based) that allow users to generate electronic documents and submit them to the relevant authorities for processing.
• Information Portals	Websites that provide traders with the information necessary to comply with the many different trade procedures. Additional features might include 'electronic access point' type functionality. In some countries, like the UK, Information Portal projects are seen as a stepping stone to wider single window ambitions.

Technological Issues

The challenge of fixing the 'crayon drawing' state of affairs often begins with defining what data should be exchanged between which parties and by what method. Reaching consensus on datasets, messaging and interoperability issues is often viewed as the first step in any single window project. Some single window programmes, such as the one in the USA, are actually rooted in detailed studies of all government departments' information requirements; with a view of first seeking to rationalise them and then standardise them to enable greater interoperability. Much effort is placed on defining a "master dataset" (so called "data modelling") and how electronic messages should be matched – the "messaging engine".

Again, without wanting to go into too much technical detail, developing the master dataset usually concerns itself with reaching agreement on standards for defining trade related information, such as what a consignment is or what does weight and volume mean. Standardisation often also concerns itself with how data should be communicated. To enable interoperability it is also essential that data elements can be related. A paper-clip or staple might serve this purpose well for paper documents. In an electronic world reference numbers are required to hold together different types of data. Reference numbers and referencing conventions currently differ significantly between systems and administrations. Examples of commonly used reference numbers include customs entry numbers, container numbers, post codes, seal numbers, consignment reference numbers, airway bill numbers, amongst many others.

CONCLUSION

As outlined, the single window concept has received considerable policy momentum in the context of trade facilitation and the desire to reduce trade compliance cost. The recent avalanche of new security related trade procedures (Grainger 2007) and desire to offset their compliance burden adds yet further drive (WCO 2007). Increasingly, the single window concept is also being adopted by developing nations and seen as strategically significant towards ensuring trade related competitiveness and economic growth (e.g. Wulf 2004). However, the single window idea is not a new one. Obstacles and implementation challenges are significant. Despite current interest, very few countries have implemented a fully functioning nationwide single window environment.

Given the diversity of stakeholders reaching consensus on standards, funding, operating and governance models, is no small task. In developed countries existing legacy systems also represent a key challenge – they cannot be easily switched off and the benefits of anything new (and unknown) needs to be proven first. Given the complexity of trade procedures and diversity of requirements, the produced cost-benefit analyse often remains sketchy (e.g. Linington 2005).

Since UN/CEFAACT Recommendation 33 was drafted technology has moved on considerably. For example, the advent of cloud computing could potentially open up new methods for information sharing that are not necessarily dependent on building physical electronic trade infrastructure. Open source implementation approaches could potentially be equally relevant. Control requirements are also somewhat shifting. Especially in the area of supply chain security it can be observed that government is gradually trying to insert itself as an integral thread into the supply chain, rather than presenting itself as an obstacle at the border (Grainger 2007). Although UN Recommendation 33 is useful, it is perhaps time to revisit UN it, taking into account current legacy systems in place, changed control requirements that expand beyond the border and across the supply chain, as well as the opportunities presented by new technologies, especially the web and cloud computing.

REFERENCES

Applegate, L. M., B.-S. Neo, et al. (1995). "Singapore TradeNet: Beyond TradeNet to the Intelligent Island " Harvard Business School Cases **Oct 10**.

ASEAN. (2005). "Agreement to Establish and Implement the ASEAN Single Window, Kuala Lumpur, 9 December 2005." Retrieved 15 April, 2010, from http://www.aseansec.org/18005.htm.

Clark, C. (2003). BPAWG Reference Model of the International Supply Chain. TBG 14, UN/CEFACT. **UN/CEFACT/BPA/BP044**.

Grainger, A. (2007). "Supply chain security: adding to a complex operational and institutional environment " World Customs Journal **1**(2): pp.17-29.

Grainger, A. (2009). A case study focusing on trade procedures as applicable to the EU import of beef and poultry products (products of animal origin). Trade Sustainability Impact Assessment (SIA) of the Association Agreement Under Negotiation Between the European Community and Mercosur: Sector Study for

Trade Facilitation. C. George, C. Kirkpatrick, M. L. Dardaineet al. Brussels, European Commission.
ICC (1999). Incoterms 2000: ICC Official Rules for the Interpretation of Trade Terms. Paris, International Chamber of Commerce.
Linington, G. (2005). International Trade Single Window and Potential Benefits to UK Business. London, SITPRO.
OECD (2001). Business Benefits of Trade Facilitation. Working Party of the Trade Committee. Paris, OECD. **TD/TC/WP(2001)21**.
OECD (2003). Quantitative Assessment of the Benefits of Trade Facilitation. Working Party of the Trade Committee. Paris, OECD. **TD/TC/WP(2003)31/Final**.
TAXUD/477/2004. (2008, 22 September). "Electronic Customs Multi-Annual Strategic Plan; 2008 YEARLY REVISION (MASP Rev 9)." Retrieved 9 April, 2010, from http://ec.europa.eu/taxation_customs/resources/documents/customs/policy_issues/e-customs_initiative/MASP_strategic_plan_en.pdf.
Teo, H.-H., B. C. Y. Tan, et al. (1997). "Organizational Transformation Using Electronic Data Interchange: The Case of TradeNet in Singapore." Journal of Management Information Systems **13**(4): 139.
UN/CEFACT (2004). Recommendation No. 33: Single Window Recommendation. CEFACT. Geneva, UN. **ECE/TRADE/352:** 37.
WCO (2007). WCO SAFE Framework of Standards.
WTO (2009). WTO Negotiations on Trade Facilitation: Compilation of members' textual proposals. Negotiating Group on Trade Facilitation, WTO. **TN/TF/W/43/Rev.19**.
Wulf, L. D. (2004). Tradenet in Ghana: Best Practice of the Use of Information Technology. Background paper prepared for the World Development Report 2005, World Bank.

ICT INTEGRATION IN FACILITATING GLOBAL LOGISTICS AND TRADE: Analysis of Initiatives from TAIWAN'S GOVERNMENT

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ABSTRACT
Many governments have put a lot of efforts to simplify transport operations, reduce customs barriers and harmonise import/export processes. Information and Communication Technology (ICT) are used in the governments to conduct paperless trade. In Asia-Pacific region, a trade facilitation plan was initiated and most of APEC member economies have prepared their individual action plans to paperless trading implementation.

At present, the development in IT, EDI and Vans had played an important role in facilitating global logistics and trade, and the Internet solutions are replacing the uses of EDI over VANs. In order to understand the role of ICT in the government for E-Trade implementation, we study the trade processes and procedures in governmental sector. A case study of local Van providers in Taiwan is used to help examining how these regarding information systems are facilitating global logistics and trade.

INTRODUCTION
Many countries in the world have endeavoured to improve their international trade; their governments adopted measures to simplify transport operations, reduce customs barriers and harmonise import/export processes. More than that, the paperless trade is denoted and Information and Communication Technology (ICT) are widely used in the governments of these countries.

In Asia-Pacific region, the implementation of paperless trade program was declared by APEC (Asia-Pacific Economic Cooperation) Ministers in 1998. Since then, most of APEC member economies have adopted their individual action plans to paperless trading implementation. They believe that cooperation among them is needed in cross-border situation and a commonly accepted trading practice should be worked out and be followed to make the cross-border process more seamless and consistent.

In order to examine how important is the that ICT implemented in the government for paperless trade, we study the trade processes and procedures in governmental sectors. The areas examined include transport operations, customs clearance and import/export processes.

A case study of local Van providers in Taiwan, e.g. Trade-van for Customs clearance and FISC (Financial Information System Company) for bank transfer, is used to help understand how these information systems facilitate global logistics and trade. Other necessary systems for facilitating import/export processes are also discussed. Therefore, the objectives of this paper are first to identify the varieties of international trade procedures in a government; second objective is to focus on government efforts to simplify trade procedures and the third to identify the role of Information and Communication Technology (ICT) in improving efficiency and effectiveness of global logistics and trade.

LITERATURE REVIEW
The Information and Communication Technology (ICT) has rapidly developed in the last two decades. Business enterprises in manufacturing or international transport, nowadays, have a number of computer systems dispersed in organisational units both within and outside the country. Indeed, the personal computer (PC) is available as both standard desktop models and net PCs (NC); they can easily boot to the organisational networks,

query/update databases, browse the Internet, send e-mail, or compose documents (including graphics or images). The networks formed are the so-called Local Area Networks (LANs) or Wide Area Networks (WANs). With the vast amount of information stored on the systems, these computer systems allow access to the right kind of information at the right time through the interconnection of computing resources both at the intra-organisational (Intranet) and inter-organisational (Extranet) levels (Angeles, 2001).

In order to facilitate every business organisation communicating with their partners, Electronic Data Interchange (EDI) has been developed to exchange structured data through agreed message and communication standards between the computer systems of trade partners. The progression of international EDI standards was also initiated on the basis of international organisation levels. In 1990, the UN Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) was formed to harmonise international EDI standards, and regional EDIFACT boards were also established to promote EDI implementation in the regions. With the advent of Internet technology, EDIFACT was re-structured into CEFACT (the United Nations Centre for Trade Facilitation and Electronic Business) in 1996. On the other hand, the implementation of EDI normally forms a Value Added Network (VAN) to provide services among the trade community. Since the 1970s, the prevailing use of the Internet has given another boost to EC because it is a low-cost alternative to the proprietary networks. (Chaffey, 2002).

THE IMPLEMENTATION OF ICT IN INTERNATIONAL TRANSPORT

In this paper container shipping and seaport are selected to examine the management information systems developed and used.

Container Shipping

The organisational structure of a container shipping company varies according to a number of factors: (1) fleet size and overall financial turnover, (2) the trade(s) in which the company is engaged, and (3) the scale of the business involved. The shipping companies conduct their business abroad by means of branch offices or agents; they act as the owners' local representatives in the clearance and discharge of the owners' vessels, and they secure cargo for shipment. Thus, many modern computer and advanced communication systems are created for the highest possible accuracy and speed of data collection and information processing. These systems provide fast documentation and up-to-the-minute cargo status reports. Some shipping companies have dedicated satellite bases and communication networks with computer centres in their headquarters or in outside hub ports, thereby providing a global data resource, which is continuously available. This enables the shippers to track the cargo movements on a 24-hour basis and to apply the materials management, Just-In-Time production, and product delivery (Stopford, 2002; Giannopoulos, 2004).

Many container shipping companies have developed an integrated VAN service for all of their clients. The VAN will be linked with the major important international VAN services of other countries, thereby providing data and information on a global basis to all the customers worldwide, or it will connect with external systems such as port terminals, truck/rail companies, Customs, and shippers/consignees, for companies' business operations. Besides, the container shipping industry has joined the development of international EDI standards in the past few years, such as SMDG in Europe or EDIFACT/CEFACT in the United Nations (UN/CEFACT, website). The experts in different aspects meet periodically for the formulation of international standards. Currently, numbers of messages developed by UN/EDIFACT and ANSI X12 are commonly implemented by the container shipping industry. The **Table** below shows the EDI messages are commonly used to share data and information with their business partners.

Table: EDI Messages Implemented by Shipping Companies

Business process	EDIFACT	ANSI X12	Business process	EDIFACT	ANSI X12
Booking Request	IFMBF	300	Loading list/loading report	COLOIN COLORE	319
Booking confirmation	IFTMIN	301	Vessel loading/unloading	COARRI	322
Import release information	COREOR	301	Vessel schedule	IFTSAI	323
Booking cancellation		303	Stowage plan	BAPLIE	324
Shipping instruction	IFTMIN	304	Gate in gate out operations	CODECO	622
Bill of lading	IFTMCS	310	Hazardous Manifest	IFTDGN IFTIAG	
Arrival notice		312	Remittance advice	REMADV	820
Customs inbound manifest	CUSCAR		Acknowledgment Application level Translator level	 APERAK CONTRL	 824 997
Status information	IFTSTA	315			

Source: Author, collected from Yangming line

The advent of Internet has helped container shipping companies provide web services to global shippers; the services include schedules, container tracking, rate inquiry, booking, shipping instruction, bill of lading processing, customized report, shipment summary, cargo tracing, shipment detail, exception reporting, event notification, and cut-off/availability (Stopford, 2002).

Seaport

A seaport provides a variety of services and operations, from a vessel's pre-arrival to its departure. In order to efficiently handle cargo or passenger in the seaport, information systems and communication technology have also played an important role in seaport operation, management, and planning. The use of ICT means the port community has come closer to taking advantage of the sharing of information to plan the individual operational functions in synchronization with the rest of the community members. Some of the data even transfers between seaports to facilitate cargo handling: the stowage plan of a container vessel, called Bayplan, for example, is always the most up-to-date and the latest available if it is communicated online.

Port Management Information Systems (PMISs) and port community networks (PCNs) are developed to facilitate port operations and services. The systems vary from port to port. Their scale and scope rely on the services that they provide to users. Following systems are included in PMISs and PCNs:

- A network system providing inter-organisational information sharing. Many leading port community network systems, such as DAKOSY in Hamburg, ADEMAR in Le Havre, FCPS in the Port of Felixstowe, INTIS in Rotterdam, PORNET in Singapore, SEAGHA in Antwerp, SHIPNET in Japan, TRADENET in the Singaporean maritime community and KL-NET in the Korean maritime community, are connecting to relevant organisations or port users, providing EDI or EC services (Lee, et al., 2000).
- A port in-house management information system, consisting of many subsystems, which facilitate processes within the port authority or port operator.
- Terminal operation systems, which may consist of different subsystems, depending on the business engaged in, either container terminal or conventional terminal.
- Customs clearance system for automatic cargo clearance (Lee-Partridge, et al., 2000).

Port information systems have to be continuously reengineered to cope with the changing communication technologies and international standards. EDI messages used in port data interchange have three formats: proprietary messages, UN/EDIFACT messages, or a combination of both. Currently, UN/EDIFACT messages, such as Customs Cargo Report - CUSCAB, In Gates and Out Gates - COPECO, Discharge and Loading - COARRI, Bay Plan -

BAPLIE, Dangerous Goods Notification - IFTDGN, Customs Declarations - CUSDEC, Customs Response - CUSRES, Container Pre-Arrival Notification - COPARN etc., are available for implementing in the port for cargo handling (UN/EDIFACT, website). The use of EDI messages may vary from port to port. Some ports may still use their own proprietary messages or regional standards, e.g. ANSI standards are commonly used in the US.

The Internet has also become a powerful medium for a seaport to interact with its users. The online networks have been accelerated to increase a port's level of quality service by making the current paper-driven or counter-based services more convenient and accessible to all the port users. Typically, port electronic commerce can be categorised into three levels, as presented in the **Table** below.

Table: Typical Functions of Port Electronic Commerce

Port information	Port EDI	Port e-business
• Shipping directory • Vessel status: vessel schedules, berth alongside, ships' data • Cargo/container track and trace • Port statistics reports	• Customs clearance • Container handling • Stowage plan • Dangerous goods	• e-application • e-service • e-order • e-billing and e-payment

Source: collected by Author

THE ROLE OF A GOVERNMENT IN THE PROCESSES OF TRADE

International trade, in general, comprises various and complicated processes in many organisations and government departments, including trading companies, commercial banks, insurance companies, international carriers, Customs, and other government agencies. These processes can also be grouped as the following four areas, i.e., import/export trade and insurance, Customs declaration, certificates and licenses, and international transport. Of which, many governmental departments or agencies are involved in the processes of international trade, especially, Customs declaration and import/export certificates and licenses.

Many forms and documents are required during Trade and Government interacts in respect of international trade. For examples, for some countries, a pre-shipment notification is required at some point (e.g., 48 hours) before the consignment is loaded. An export or import declaration is required in order to move the consignment. Indeed, most governments require certificates from an overseas agency, the reverse is also true. Therefore, Trade may require governments to issue various types of certificates in relation to export consignments. In many cases, supporting paper documents are required even where the main declaration or license application can be made in electronic form. This declaration is also used to create trade statistics and to assess the duty payable. Other declarations may have to be made for particular types of cargo.

Currently, many governmental systems are developed to fulfill trade processes for import and export. All customs declarations are made electronically at time of import, but applications for licenses and other declarations are made to stand alone systems or manual. Some paper is extensively used to support declarations and applications and multiple agencies inspecting at the border. And more, financial/statistical and security regimes are integrated within declaration messages.

In Asia-Pacific region, the APEC (Asia-Pacific Economic Cooperation) Sub-Committee on Customs Procedures (SCCP) has been working towards the harmonisation and simplification of Customs procedures in the Asia-Pacific region since 1994. Its activities include the simplification and rationalisation of customs and other administrative procedures that hinder, delay or increase the cost of moving goods across international borders. In 1998, APEC Ministers declared the implementation of paperless trade program for the purpose of facilitating international trade. Since then, most of APEC member economies have prepared their individual action plans to paperless trading implementation (APEC, 2007). They believe that cooperation among them is needed in cross-border situation and a commonly accepted trading practice should be worked out and be followed to make the cross-border process more seamless and consistent.

THE SUCCESSFUL CASES IN ICT IMPLEMENTATION IN TAIWAN

As discussed in earlier sections , ICT has been widely used in container shipping and port industry. Additional examples of ICT implementation and trade facilitation plan by Taiwan's government are analysed in this section

Tradevan

In 1990, Taiwan intended to implement the use of information system in Customs clearance for benefiting the import/export processes in the government; a cargo clearance automation planning and promotion (CCAPP) project was initiated. After the project completed in 1995, a private organization of Trade-Van Information Services was formed in 1996. Its major Shareholders included eight leading private corporations.
Trade-Van is a kind of value-added network. EDI was widely used in formation exchange in the beginning. After the advent of Internet, Internet technology is introduced in most of its systems. The major goal of Trade-Van is to improve and expand a range of value added information services, including customs clearance automation and paperless trading.

The success of customs clearance automation system helped the large number of Taiwan manufacturing companies to export their products across the globe. Currently, almost all customs clearance in Taiwan is declared through Trade-Van network. To better service clients, e-commerce services are developed to provide a one stop service for conducting international trade through value added information exchange services to the international trading community.

Trade-Van started from customs cargo clearance and has developed a range of web based front end systems to enhance the competitive advantage and business performance of its customers, providing the b2b e-commerce field across Asia to expand our network reach and increase the effectiveness of our service offerings.

FISC

The Financial Information Service Co. (FISC) was found by Taiwan's Ministry of Finance and 42 other public and private-owned financial institutions in 1998. Its purpose is to provide financial institutions with better and more flexible inter-bank operations and services. This company also owns and operates Financial Information Service Centre, responsible for the continuous planning and development of inter-bank information systems for financial institutions, and for the administration of the inter-bank financial information network.

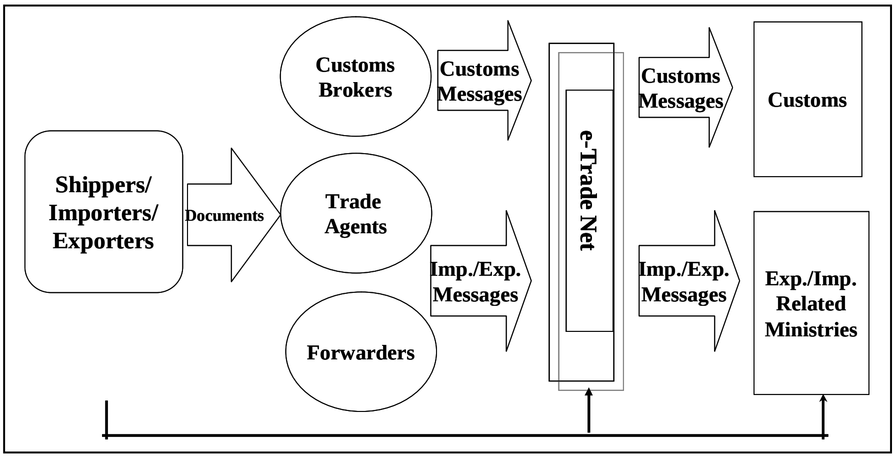
Faced with a fast-changing financial service environment, the liberation of private-owned companies to value-added networks, and increasing global competition, the Service Centre was also transformed to private company.

FISC operations include financial chip cards, a shared CD/ATM system, inter-bank remittances, bulk payments, credit card services, debit card services, financial XML, FEDI, Internet banking, mobile banking systems, inquiry services, information system disaster recovery, and data media storage. The FISC provides services and value-added activities to individuals and business organisations.

Trade Facilitation Plan

In response to the APEC's trade facilitation plan, Taiwan has established a task force under the Ministry of Economic Affairs. A trade facilitation plan was initiated in 2003 and a new trade network started to operate in 2005. The **Figure 1** shows the new process which shippers or importers/exporters complete government procedures through e-trade net. This one-stop shopping platform provides a simple, easy and paperless way to accomplish customs declaration and import/export endorsements from various government departments, such as Bureau of Foreign Trade, Bureau of Standards, Metrology and Inspection, National Science Council, and Council of Agriculture.

Figure 1: Flow Chart of E-trade Platform



Source: author

CONCLUSIONS

Many countries have endeavoured to promote their international trade, in which, Information and Communication Technology (ICT) play an important role for facilitating international trade processes. At present, modern information systems and value-added networks are used in international transport, seaports, Customs clearance and other government departments. International organisations are also working towards the harmonisation of trade procedure, the reduction of customs and other barriers through regional cooperation. In this [paper, cases from Taiwan with Government's initiatives are examined. Taiwan has made a lot of efforts to develop information systems in facilitating international trade. The success of Trade-van for Customs clearance, FISC for bank transfer and e-trade net for international trade has assisted in paperless current trade process in government. From this new one-stop paperless platform, Trade can declare Customs clearance and other import/export licenses. This sets an example for other countries to adopt to achieve ICT integration in facilitating global logistics and trade.

REFERENCES

Angeles, R. (2001), "Creating a Digital Market Presence: lessons in extranet implementation", Internet Research: Electronic Networking Applications and Policy, Vol. 11, No. 2, pp. 167-184

APEC (2007), "APEC's Second Trade Facilitation Action Plan", APEC Secretariat

Chaffey, D. (2002), "E-Business and E-Commerce Management: strategy, implementation and practice", Prentice Hall

Giannopoulos, G. A. (2004), "The Application of Information and Communication Technologies in Transport", European Journal of Operational Research, 152, pp.302-320

Lee, T.W.; Park, N.K.; Joint, J.F. and Kim, W.G. (2000), "A New Efficient EDI System for Container Cargo Logistics", Maritime Policy and Management, Vol. 27, No. 2, pp. 133-144

Lee-Partridge, J.E.; Teo, T.S.H. and Lim, V.K.G. (2000), "Information Technology Management: the case of Port of Singapore Authority", Journal of Strategic Information Systems, Vol. 9, pp. 85-99

Stopford, M. (2002), "E-commerce-implications, opportunities and threats for the shipping business", International Journal of Transport Management, Vol. 1, pp.55-67

SECTION 3 – Supply Chain Performance Assessment

WHAT IS THE TRUE TOTAL COST OF OUTSOURCING OF SUPPLY CHAIN PROCESSES? A SERVICE QUALITY PERSPECTIVE

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ABSTRACT

As companies now compete on a global basis, geographical dispersion of business units and processes has become commonplace. Furthermore, outsourcing has become an important source of competitive advantage for many firms, owing to the projected long term cost savings that can be achieved by moving high overhead activities to a low cost location. However, further down the line, are the benefits realised as anticipated? By means of a longitudinal study, carried out over a period of five years, this paper examines this much-discussed topic by focussing on contributing success factors to the outsourcing decision. In particular, we analyze the main service quality dimensions, practical customer service issues and management implications of outsourcing key business processes (such as manufacturing, logistics and IT) in manufacturing organisations. Following an extensive literature review, gaps regarding research into the management of outsourcing relationships, particularly with respect to customer service were identified. Our overall aim was to explore outsourcing relationships in the manufacturing industry from a customer service perspective and to provide a relationship management framework to assist organizations to attain sustainable relationships with outsourcing partners. Our specific objectives were to determine whether cost savings had been realised, examine the factors that influence and contribute to service quality in an outsourcing relationship and evaluate how experience shapes future outsourcing strategy.

Over a five year period, results from 107 questionnaires (3% response rate) and 15 interviews that investigated service quality from the outsourcer's perspective were analysed. Our research revealed that the majority of companies felt that expected outsourcing benefits were not fully achieved. The most influential factors affecting outsourcing relationships and service quality were found to be cost realisation, consistency of quality, trust building, communication and responsiveness. Of these, trust building and ongoing close collaboration with outsourcing partners were found to be key to maintaining successful outsourcing relationships. They were also crucial to keeping long term running costs under control. The resulting relationship management framework seeks to assist in assessing all service quality aspects and costs, prior to the outsourcing decision being made. Elements include practical supply chain issues (e.g. supplier capability, lock in effect), management issues (partner selection, information sharing) and critically; service quality issues (complaints, costs). Our intention is that this framework, if used alongside performance measures and practical implementation methods, can be used to make a realistic assessment of total outsourcing costs for supply chain processes and pave the way towards ensuring a sustainable, long term outsourcing culture within organisations.

INTRODUCTION AND LITERATURE OVERVIEW

The ever-increasing options open to outsourcers regarding suppliers, location, transport methods and communication technologies mean that the questions of what, where and how to outsource remain key topics in management research (Hätönen and Eriksson, 2009, McIver, 2008, Beaumont, N., Khan, Z. 2005). Table 1 summarises the most prominent of the recent contributions.

	Authors	Focus
What?	Cronk & Sharp (1995)	Competency decision framework
	Lonsdale (1999)	Core activity and supplier influence risk management model
	Humphreys et al (2002)	Make vs. Buy expert system
	Currie (2003)	Knowledge risk management framework
	Aubert et al (2005)	Outsourcing decision risk assessment framework
	McIvor (2008)	Competency decision framework
Where?	Graf & Mudambi (2005)	Location decision models
	Egger & Falkinger (2006)	Intermediate goods outsourcing location
	Bunyaratavei et al (2007)	Location decision key factors
	Lo and Liu (2009)	Location decision factors: China vs. India
How?	Vokuka et al (1996)	Supplier evaluation and selection prototype expert system
	Fraering & Prasad (1999)	Total cost of ownership
	Vining & Globerman (1999)	Outsourcing implementation framework
	Zhu et al (2001)	Implementation process step implication
	Fawcett & Birou (1992)	JIT and global sourcing
	Momme & Hyolby (2002)	Strategic and operational outsourcing framework
	Franceschini & Galetto (2003)	Outsourcing process model
	Lalwani et al (2007)	Operation transition contextualization framework
	Huang et al (2009)	R&D sourcing model

TABLE 1 – SUMMARY OF OUTSOURCING MANAGEMENT APPROACHES
(Yamamura, 2009)

Transformation of operations contains much uncertainty and risk, with a high percentage of outsourcing relationships ending in failure (Pawar, et al 2004). There have been a number of approaches to tackling both the transitional and long term issues raised by outsourcing. Here we have chosen to focus on service quality, as this is a major determinant of customer service. It is also an area where hidden costs can lie.

In the current dynamic manufacturing context, organizations are expanding their operations worldwide and must compete on a global basis. Along with lower total system cost, higher quality and better delivery performance, customers now expect a shorter product life cycle, reduced time to market and an innovative and customized product (Underdown and Talluri, 2002). Businesses are becoming ever more complex, and face a growing number of risks and potential consequences. Even major organizations are affected by events that are distant in terms both of location and industrial sector, and over which they have no control (Waters, 2007).

The term outsourcing is widely used in varying contexts but can broadly be defined as 'the transfer of activities and processes previously conducted internally to an external party' (Ellram and Billington, 2001). International outsourcing (also known as offshoring) carries the most risk, owing to its more remote location. The current highly competitive environment has led to the evolution of a so-called outsourcing economy, which is characterized by an increased focus on core organizational activities and simultaneous leveraging of external resources, skill, knowledge, capabilities and competences through outsourcing (Hätönen and Eriksson, 2009). Today, the most significant outsourcing decision challenges are recognizing the firm's key competence areas, finding suppliers to provide value to the rest of the operations, and managing the resulting global network of suppliers and partners (Quinn, 2000). If the decision is made to outsource core functions selection of the right partner(s) is a major determinant of factor as the outcome of this relationship can make or break the long term competitiveness of the organisation in the global marketplace.

Prior to an outsourcing decision being made, managers consider various factors, both tangibles (such as cost, facilities, human resources) and intangibles (such as strategy, quality) (Pawar et al, 2004). In many cases, cost savings are realized almost instantaneously, but the long-term impact on the service quality customers receive (such as long lead times, delivery delays and quality related issues) is still largely unexplored. Many contributions in the literature have revealed that the transformations of operations contain considerable uncertainties. For instance, many firms are unable to fully contextualize factors such as infrastructure (energy, material, transport and communication, etc.), education, training, local and national regulations, culture, and organization networks (Pawar et.al, 2004). A Gartner analyst stated that during the period 2005 to 2008, 60% of organizations who outsourced core activities faced customer defections and incur hidden costs that would cancel out or even exceed savings (Kshetri, 2007). Furthermore, Pawar et al (2007) found that many were not able to transfer their operations efficiently, and up to half of the outsourcing relationships worldwide had failed within five years.

There have been a number of approaches to tackle outsourcing problems in operation transition and management; these have taken the form of outsourcing process models, outsourcing frameworks or expert systems. However, according to Jain et al (2005), no approach has taken a customer-centric service perspective. As service quality can often make the difference between business success and failure, this aspect is very significant (Leonard et al, 1988). It is necessary to identify the key service quality dimensions - as defined by Lovelock 1988 - by investigating how outsourcers evaluate the service they receive; and to create an appropriate response framework in order to diminish, counteract, or ideally eliminate potential adverse effects from this perspective. Therefore, in this paper, the authors examine outsourcing relationships from the customer service perspective, and provide guidelines on estimating the true cost of outsourcing supply chain processes.

OBJECTIVES

Given that the broad aim of this study is to explore the success of supply chain-related outsourcing relationships from the customer service perspective, the specific objectives are to:

- understand and contextualise the service quality,
- observe the change over time in the key service dimensions,
- determine the factors that constitute the full cost of outsourcing.

RESEARCH METHODOLOGY

A mixed methods approach, using a combination of qualitative (semi-structured interviews) and quantitative methods (questionnaires) was followed to allow for both large scale and in-depth information to be collected. The questionnaire was carried out over a five year period (2004-2009), involving three separate mailings. The questions from the main body of the questionnaire (sections 2 and 3) involved subjective answering along a five point Likert scale and covered the following areas;

1. General information about the company (number of employees, location, turnover, etc.)
2. Profile of outsourcing activities (which processes, to which location, reasons for outsourcing, etc.)

3. Satisfaction with outsourcing (service quality; responsiveness, reliability, communication, hassle factor, customer complaints, etc.)

A response rate to the questionnaires of approximately 3% was achieved. This resulted in 107 usable questionnaires being analysed. Over the same five year period, 15 semi structured interviews with supply chain professionals at 15 organisations were carried out. The industries represented included automotive, opto-digital, telecommunications, heating equipment, textiles, electronics, and food. Each interview lasted between 60 and 90 minutes. Respondents were asked to formulate their answers on the basis of recent (past five years) outsourcing experience. Questions were open ended and the interview protocol was designed to probe respondents' opinions as well as experiences. Respondents were also free to suggest their own additional discussion topics. Interviews were transcribed for analysis, allowing for direct comparison of both differences and similarities in responses.

RESULTS AND DISCUSSION

Analysis of the questionnaires highlighted the following issues:

- 78% of companies cited cost reduction as the main reason for outsourcing. Expertise and increased flexibility were the second and third most popular reasons.
- 84% of companies considered service quality to be the most important factor when selecting an outsourcing partner
- 49% of companies were not satisfied with the overall service levels they received (averaged across various factors including hassle factor, late deliveries, customer complaints, etc.)
- 71% of companies were not fully satisfied with the service quality that they received
- 79% of companies felt that cost reductions were not fully realised

Indicative profiles and responses of a selection of the case companies is shown in Table 2 below.

Company	A	B	C
Position	Outsourcer	Outsourcer	Outsourcer
Location	Japan	Japan	UK
Location of supplier	Japan, China, Korea and Thailand	Japan	Worldwide
Industry	Automotive	Automotive supplier	Opto-digital product
Outsourced activity	R&D, machine tool manufacturing	Prototype system development	Parts production and service
Single/ Multiple	Multiple sourcing	Multiple sourcing	Multiple sourcing
Relationship types	Long-term close relationships with partner companies in Japan. A different outsourcing	Short term contracts	Depends on the criticality of the supply but aim to not be 'locked-in' to one

	strategy for overseas companies exists (e.g. cost reduction or expertise)		supplier Short term arms length relationship with non-critical suppliers. Long-term relationship with critical suppliers.
Reasons for outsourcing	1. Expertise 2. Focus on core activity 3. Cost reduction	1. Expertise 2. Cost reduction	1. Expertise 2. Cost reduction 3. Enhance economy of scale
Ways to improve relationship	Share the value Control over process Share information Clear specification of the requirements	Clear and precise specification of the requirements Work with company that has similar work culture and values	Regular business meetings Regular Quality/ Cost/Delivery reports Measure performance also from relationship quality perspective (e.g. commitment and responsiveness)
Unplanned costs	Overseas suppliers not satisfactory in quality and lead time. Locked into Japanese supplier overseas, so in poor bargaining position.	Late delivery	Underperformance of suppliers Communication issues caused by cultural misunderstandings Politics and regulations
Future scenario	Common outsourcing strategy to keep the core activity in-house.	Work closely and more efficiently with the current outsourcees.	Promote global sourcing to select competitive partner. Educate employees to overcome cultural gap.

TABLE 2 – INDICATIVE PROFILES AND RESPONSES OF CASE COMPANIES

Both the survey and interviews reinforced our assumptions that expected outsourcing benefits were not fully realised and that costs were underestimated. Furthermore, problems existed regarding consistency of quality, lack of trust and/or a trust building atmosphere, lack of open communication between the parties and responsiveness of the supply company (outsourcee). Trust and relationship management (collaboration and responsiveness) were found to have the greatest impact on keeping costs within budget and subsequently on long term success.

The resulting relationship management framework (see Figure 1) seeks to assist in assessing all service quality aspects and costs, prior to the outsourcing decision being made. Elements include practical supply chain issues (e.g. supplier capability, lock in effect), management issues (partner selection, information sharing) and critically;

service quality issues (complaints, costs). These elements form the focal construct of true cost estimation, which in turn determines the chances of a long term sustainable relationship between the parties. The next logical step is to provide guidelines for performance measures and practical implementation methods.

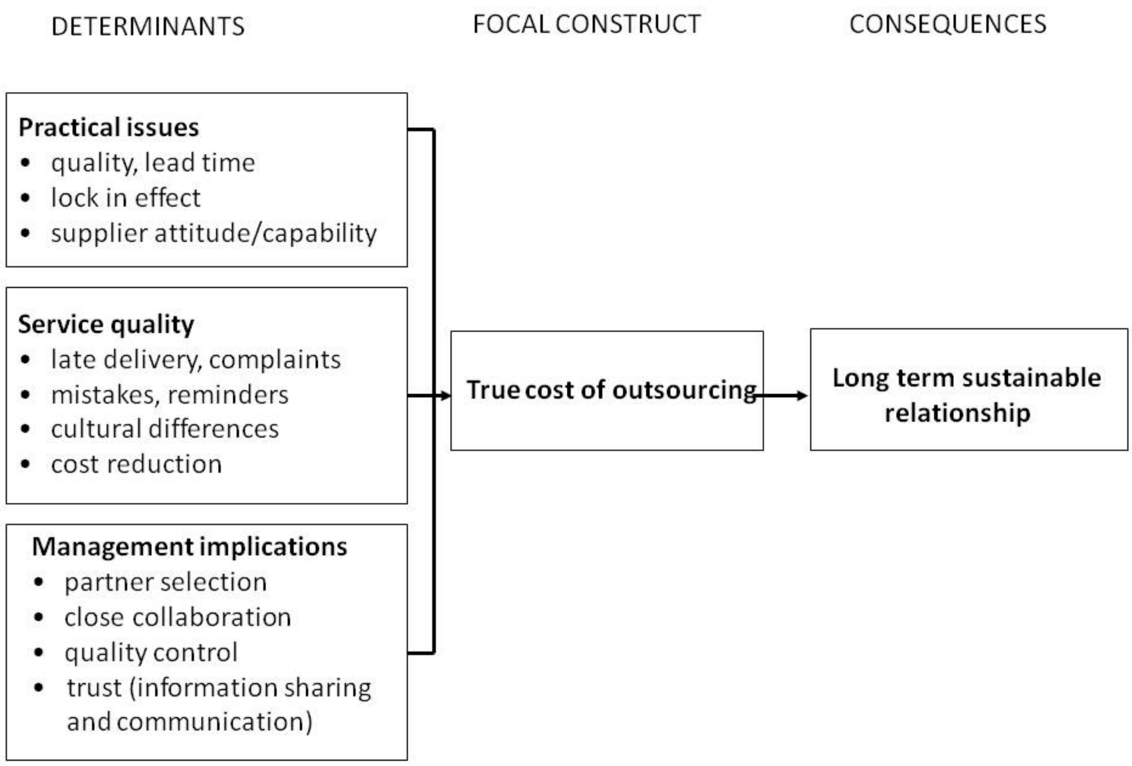

FIGURE 1 – OUTSOURCING COST ASSESSEMENT FRAMEWORK

CONCLUSIONS

In order to ensure that outsourcing relationships are successful in the long term and for cost-benefit predictions to come to fruition, firms must be realistic about the time and resources required to establish a trust-based relationship with their chosen partners. Our research indicates that outsourcing success is closely linked to service quality, reinforced by strong support for customer service considerations. The barriers that can result from (mis-)communication have to be addressed and managed at the earliest stages if outsourcing is to become successfully integrated into the organisation's culture and processes. To help ensure that channels of communication remain open, trust and relationship building incentives such as Communities of Practice should be encouraged.

As the relationship management framework was developed with companies in the manufacturing sector, additional testing (in particular empirically-based comparative studies) in other sectors is desirable to enhance its validity. Furthermore performance measures need to be further developed and tested.

This framework, together with the suggested measures and implementation methods, paves the way towards developing practical and realistic solutions for ensuring a sustainable, quality-focused outsourcing culture within organisations.

REFERENCES

Aubert, B.A., Patry, M., Rivard, S., 2005. A framework for information technology outsourcing risk management, ACM SIGMIS Database, 36, 4, 9-28.

Beaumont, N., Khan, Z. 2005. A taxonomy of refereed outsourcing literature, Monash University Business and Economics Working Paper 22/05.

Bunyaratavej, K., Hahn, E.D., Doh, J.P., 2007. International offshoring of services: A parity study, Journal of International Management, 13, 7-21.

Currie, L.W., 2003. A knowledge-based risk assessment framework for evaluating web-enabled application outsourcing projects, International Journal of Project Management, 21, 207-217.

Cronk, J., Sharp, J. 1995. A framework for deciding what to outsource in information technology, Journal of Information Technology, 10 (4), 259-268.

Egger, H., Falkinger, J., 2005. The role of public infrastructure and subsidies for firm location and international outsourcing, European Economic Review, 50, 1993-2015.

Ellram, L., Billington, C. 2001. Purchasing leverage considerations in the outsourcing decision, European Journal of Purchasing & Supply Management, 7 (1), 15-27.

Fawcett, S.E., Birou, L.M., 1992, Exploring the Logistics Interface Between Global sourcing and JIT sourcing, International Journal of Physical Distribution & Logistics Management, 22 (1), 3-14.

Fraering, M., Prasad, S., 1999. International sourcing and logistics: an integrated model, Logistics Information Management, 12 (6), 451-460.

Franceschini, F., Galetto, M., 2003. Outsourcing: guidelines for a structured approach, Benchmarking: An International Journal, 10 (3), 246-260.

Graf, M., Mudambi, S.M., 2005. The outsourcing of IT-enabled business processes: A conceptual model of the location decision, Journal of International Management, 11 (2), 253– 268.

Hätönen, J., Eriksson, T., 2009. 30+ years of research and practice of outsourcing-Exploring the past and anticipating the future, Journal of International Management, 15 (2), 142-155.

Huang, Y., Khanna, T., 2003. Can India overtake China?, *Foreign Policy*, 137, 74−81.

Humphreys, P., Mclvor, R., Huang, G., 2002. An expert system for evaluating the make or buy decision, Computers & Industrial Engineering, 42 (2-4), 567-585.

Jain,P., Lalwani, C.S., Pawar, K.S, Shah, J., Thoben, K.D., Eschenbacher, J. 2005. A case for contextualisation outsourcing framework including customer service' in IEEE International Conference on Service Operations and Logistics, and informatics, Beijing, China.

Kshetri, N. 2007. Institutional factors affecting offshore business process and IT outsourcing, Journal of International Management, 13, 38-56.

Lalwani, C.S., Pawar, K.S., Shah, J., 2007. Contextualisation framework for the manufacturing supply chain, International Journal of Production Economics, 106 (1), 1.

Leonard, L.B., Parasuraman, A., Zeithamal, V.A., 1988. The service quality puzzle, Business Horizon, 31(5), 35-43.

Lo, C.P., Liu, B.J., 2009. Why India is mainly engaged in offshore service activities, while China is disproportionately engaged in manufacturing, China Economic Review, 20 (2), 236-245.

Lonsdale, C., 1999. Effectively managing vertical supply relationships: a risk management model for outsourcing, Supply Chain Management: An International Journal, 4 (4), 176-183.

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.

McIvor, R., 2008. What is the right outsourcing strategy for your process?, European Management Journal, 26, 24– 34.

Mommes, J., Hvolby, H., 2002, An outsourcing framework: action research in the heavy industry sector, European Journal of Purchasing & Supply Management, 8, 185-196.

Pandit, P, 2004. Investigation into the impact of outsourcing on customer service, Nottingham University Business School, unpublished dissertation.

Pawar, K.S., Gupta, A., Lalwani, C.S., Shah, J., Ghosh, D., Eschenbacher, J., 2004. Outsourcing to India, 37th Annual Convention of OR Society of India, IIM, Ahmebadad, India.

Pawar, K.S., Lalwani, C.S., Shah, J. 2007. Analysis of outsourcer and outsource relationship for global manufacturing supply chains, International conference on industrial management and systems management, IESM, Beijing, China.

Quinn, J.B., 2000. Outsourcing innovation: the new engine of growth, Sloan Management Review, 41 (4), 13-28.

Shah, M, 2005. An investigation into the level of customer service received by UK companies outsourcing to India, China and Eastern Europe, Nottingham University Business School, unpublished dissertation.

Underdown, R., Talluri, S., 2002. Cycle of success: a strategy for becoming agile through benchmarking, Benchmarking: An International Journal, 9 (3), 278-292.

Vining A., Globerman S., 1999. A conceptual framework to understand the outsourcing decision, European Management Journal, 17 (6), 645-654.

Vokuka, R.J., Choobineh, J., Vadi, L., 1996. A prototype expert system for the evaluation and selection of potential suppliers, International Journal of Operation & Production Management, 16 (12), 106-127.

Waters, C.D.J., 2007. Supply Chain Risk Management: vulnerability and resilience in logistics, Kogan Page, London.

Yamamura, N, 2009. Exploring manufacturing industry outsourcing relationships from a customer service perspective, Nottingham University Business School, unpublished dissertation.

Zhu, Z., Hsu, K., Lillie, J., 2001, Outsourcing- a strategic move: the process and ingredient for success, Management Decision, 39 (5), 373-378.

A MODEL FOR SUPPLY CHAIN VISIBILITY ASSESSMENT

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ABSTRACT
This paper seeks to analyse Supply Chain Visibility (SCV) which is ill-defined and to provide a mathematical model of SCV so as to assess it objectively for supply chain performance improvement. The characteristics of SCV are conceptually analysed and a mathematical model based on metric entropy is proposed to provide a novel method for assessing SCV.

Keywords Supply chain visibility, Supply chain visibility assessment, Supply chain performance assessment, Entropy

INTRODUCTION
With globalisation, supply chains are becoming increasingly complex and companies are more aware of the need to have better Supply Chain Visibility (SCV). Enslow (2006) reports that the lack of supply chain process visibility is a main concern for about 79% of the 150 large companies surveyed globally. This is verified by another recent survey of 400 supply chain executives worldwide (IBM 2009). Presently, SCV is a favourite jargon in the supply chain management community with over 7,510,000 entries found on the Web (www.yahoo.com, 9 Sept. 2009). However, it remains an ill-defined and poorly understood concept in the literature (Barratt and Oke 2007). Indeed, SCV is a complex issue that involves people, process, technology, and information flows. From an IT perspective, SCV refers to an organization's ability to collect and analyze distributed data, generate specific recommendations, and match insights to strategy (Tohamy et al. 2003). Bartlett et al. (2007) have shown that increased supply chain visibility can be achieved through collaboration between the suppliers and customers. While an increase in available supply chain data provides the illusion of visibility, it also adds to a company's challenges. Moreover, 90% of all supply chains report that their global supply chain technology is inadequate to provide their finance organization with the timely information it requires for budget and cash flow planning and management. The lack of visibility is especially crippling for large supply chains, which can have pipeline inventory of $1 billion. Poor visibility and uncoordinated multi-tier processes for these companies can result in significant "just in case" inventory carrying costs, premium freight expenses, and extended cycle times.

SCV is an emergent area of interest for both practice and academe, due to the advent of advanced IT technologies such as RFID and GPS (O'Neill and Newton 2004; Huo and Jiang 2007; Melski et al. 2008). In spite of its practical relevance, there is confusion and misunderstanding about SCV, and there is no commonly accepted definition of SCV (Francis 2008). Though there are some definitions for SCV (Tohamy et al. 2003; Rao 2004; McCrea 2005; Vitasek 2006; Barratt and Oke 2007; Hsiao-Lan and Wang 2007; Francis 2008; Zhang et al. 2008), they address SCV from different perspectives and have not captured all of the meaning, function and essence of SCV holistically. SCV can be logically decomposed into inventory, demand, and logistics visibility, based on the information sources available (Goh et al. 2009).

LITERATURE REVIEW

The current research on SCV mainly focuses on its importance, which can be summarised into three research streams: benefits of SCV based on RFID and other enabling technologies, impact of inventory information inaccuracy, and the impact of SCV on supply chain performance. Further, we conduct a literature review on entropy for SCV.

Benefits of SCV based on RFID and other enabling technologies

SCV can be significantly improved using advanced Auto-ID capture technologies, especially, RFID which has an inherent ability to reveal item-level product information. Zhou (2009) models the benefits of item-level information visibility through reduced randomness that is a function of the scale of the information system, the distribution of the sample space, the control variables, and the production functions. Ustundag and Tanyas (2009) use simulation to determine the expected benefits of an integrated RFID system for a three-echelon supply chain obtained through performance improvement in efficiency, accuracy, and security as well as visibility. Uçkun et al. (2008) focus on finding the optimal investment levels for profit maximization by reducing inventory inaccuracy. The optimal level of investment is examined under two scenarios: with and without SCV between the warehouses. The effect on manufacturers and retailers of attaching RFID tags at the item level in a vendor managed inventory system has been investigated by Szmerekovsky and Zhang (2008), who studied how visibility by sharing of the tag price can be used to coordinate the supply chain and how it can be exploited in manufacturer and retailer dominated systems.

The impact of RFID and the Electronic Product Code (EPC) network on mobile B2B eCommerce is studied in Fosso et al. (2008). Such enabling technologies are able to automatically trigger, cancel, or automate some business processes and provide visibility by fostering a higher level of information sharing and synchronization between supply chain members. A cost-benefit analysis of applying RFID / micro electro-mechanical system technology to manage ordnance inventory using a valuation approach combining a multi-criteria tool for the valuation of qualitative factors with a Monte-Carlo simulation of anticipated financial factors is reported in Doerr et al.(2006). Bottani and Rizzi (2008) also provide a quantitative assessment of the impact of RFID technology and EPC system on the main processes of a fast-moving consumer goods supply chain. However, challenges and obstacles to RFID adoption still persist (Wu et al. 2006). Law and Ngai (2007) have investigated the relationships between extent of BPI, the success of ERP adoption, and organizational performance and investigated the associations between the outcomes of these initiatives and organizational factors as strategic intent, senior management support, and the status of the IT function within a company. The Virtual Warehouse System (VWS) is a state-of-the-art real-time global visibility solution for inventory management (Bailey and Francis 2008). Landers et al. (2000) have reported the benefits of a VWS using a case study for field repair service.

Impact of inventory information inaccuracy

Due to inventory inaccuracy, visibility is still a major issue confronting inventory management systems using AIDC technologies (Sahin and Dallery 2009). Recent research suggests that it is unfair to assume that the availability of error free data on the flow of goods through an inventory system as well as the on-hand inventory level in facilities where advanced item AIDC technologies are used leads to an accurate inventory status (Sahin et al. 2008). These inaccuracies result from replenishment errors, employee theft, shoplifting, improper handling of damaged merchandise, imperfect inventory audits, and incorrect recording of sales. Rekik et al. (2009) have analyzed the problem of store theft by optimizing the holding cost under a service level constraint. Further, Sahin & Dallery (2009) have attempted to quantify the economic impact of poor visibility caused by inventory inaccuracy using a newsvendor framework for a wholesaler and retailers, subject to inventory data inaccuracies. An assessment of the effect of the various actions such as the deployment of a new data capture technology to tackle inventory inaccuracy is also studied. Fleisch and Tellkamp (2005), through a simulation of a three echelon supply chain, show that better inventory visibility by eliminating inventory inaccuracy can reduce supply chain costs as well as the out-of-stock level. The same conclusion has been drawn by another simulation of a two-echelon inventory system consisting of a retailer, distribution center, and supplier that includes multiple item types and using cycle counting as the corrective action (Gumrukcu et al. 2008).

Impact of SCV on supply chain performance

SCV is critical for supply chain performance improvement and SCV is identified as a significant performance indicator (Daugherty et al. 2006) who also discussed the importance of measuring SCV. However, there is no measurement method yet. Chan (2003), through AHP, presents a formalisation of both quantitative and qualitative performance measurements for easy representation and understanding using visibility. Berry and Naim (1996) simulate the implications of various supply chain redesign strategies for the introduction of an inventory visibility system to a European PC company. The benefits of SCV and its improvement based on a global demand supply network are presented in a case study (Kaipia and Hartiala 2006).

Entropy for SCV

Entropy was first introduced from the classical thermodynamic system as a quantitative entity (Freire et al. 1994; Lei et al. 2005). It was extended by Maxwell, Boltzmann and Gibbs in the late 1800's into the statistical mechanics domain through the new "molecular theory" of gases. In classical thermodynamics, entropy was used to deal with single extensive systems, whereas in statistical mechanics, it was used to describe the role of the tiny constituents of the system (Jorgensen and Svirezhev 2004). The macroscopic state of the system is specified by a probabilistic distribution on the microstates that are accessible to a system in the course of its thermal fluctuations. Thus, entropy is defined over two different levels of description of a given system. Uncertainty is given by the Gibbs entropy formula, with a discrete set of microstates, if E_i is the energy of microstate i, and p_i is its probability that it occurs during the system's fluctuations, then the entropy (S) of the system with Boltzmann's k_B is $S= -k_B \Sigma p_i \ln(p_i)$.

Entropy is also used in quantum mechanics. Thus, it is no surprise that entropy is handled by two disciplines in much the same way. The quantum mechanical definition of entropy is same as that given for statistical mechanics (Wright and Rutledge 1996). The only difference lies in how the probabilities are calculated. Quantum mechanics has its own particular rules for doing that, but they are not relevant to the fundamental definition of entropy. As in the previous case, P_i's are microstate probabilities, and they must be calculated for the same macrostate.

The first major excursion of entropy into new domains (Jorgensen and Svirezhev 2004; Paulus et al. 2005) is due to Shannon, widely recognized as the father of modern communication and information theory (Shannon and Weaver 1998). In this paper, we extend entropy to SCV assessment. Our argument for doing so is as follows. In Shannon's information theory, entropy measures the uncertainty associated with a random variable, which for our purposes can be thought of as the visibility within a supply chain that is an unknown value, which may change each time it is inspected by the system. In the same argument presented earlier for entropy, this visibility exists at the macroscopic and "molecular" levels of the supply chain. In short, we assess SCV by attempting to measure the average value of the visibility content using Shannon's information entropy, i.e. $H(\text{Visibility}) = -k_b \Sigma p_i \log(p_i)$.

THEORETIC MODEL FOR SUPPLY CHAIN VISIBILITY

Goh et al. (2009) reviews the existing SCV definitions to provide a conceptual analysis for SCV. Based on the definition proposed in this paper, SCV is the capability of a supply chain actor (or player) to have access to or to provide the required timely information/knowledge involved in the supply chain from/to relevant supply chain partners for better decision support. There are two types of capability, namely, the capability to access information available in a supply chain, and the capability to provide information available in a supply chain. Likewise, information / knowledge focuses on the information or knowledge about physical entities in a supply chain such as the stock level in a certain warehouse which can be accessed via an IT system. Based on the above understanding of SCV, a supply chain can be constructed such that there are *m* actors/players and *n* information items/resources sharing in the supply chain, which is denoted by a four-tuple *SC = (A, I, C, P)*, where

$A = \{a_1, a_2, \ldots, a_m\}$ is a finite, non-empty set of the actors in a supply chain;
$I = \{i_1, i_2, \ldots, i_n\}$ is a finite, non-empty set of information items to be shared among actors in a supply chain;
$C \subseteq A \times I$, denotes all possible relations between actors A and information items I;
$P \subseteq I \times A$, denotes all possible relations between information items I and actors A.

Note that *C* captures the capability of accessing information in the chain while *P* captures the capability of providing information. Note also that for any specific information item, only one actor can provide it. The joint relation of C and P forms the visibility between the two actors. Let relation $\Omega \subseteq A \times I \times A$ capture the visibility from an actor to another in terms of an information item.

We now propose some notations on supply chain visibility. Specifically, for a supply chain with *SC = (A, I, C, P),* a measurable element called Visibility Channel (VC) based on the relations of the key characteristics of SCV is defined as follows:

Definition 1:
A VC of a supply chain is a 3-tuple $(a_j, i_k, a_l) \in \Omega \subseteq A \times I \times A$, representing the visibility of actor a_j to a_l on information item i_k, where $a_j, a_l \in A$, $i_k \in I$, $(a_j, i_k) \subseteq C$ and $(i_k, a_l) \subseteq P$.

Definition 2:
A VC $\omega = (a_j, i_k, a_l) \in \Omega \subseteq A \times I \times A$ is open if (a_j, i_k) and (i_k, a_l) are valid, else it is closed.

VC is the measurable element for SCV which has two states: open and closed. With the notation of VC, we are ready to define the assessment functions for *SCV*. Based on the two capabilities highlighted above, i.e., capability of accessing information and capability of providing information, these two capabilities can be treated as key characteristics of SCV as they can be defined abstractly as a primitive element for a mathematical model to conceptualise SCV formally. Thus, SCV can be described and characterized in terms of information items, which are stated in detail in what follows. For any actor $a_i \in A$ in a supply chain, it has always a *visibility* of another partner actor $a_j \in A$ via an information item $i_k \in I$. Then, a typical SCV framework can be formulated as a four-tuple *V = (SC, Ω,* ***B****, μ) based on VC*, where
SC represents a typical supply chain;
$\Omega \subseteq A \times I \times A$ represents a set of VCs;
B *is a σ-algebra over Ω;*
μ: ***B*** *–>[0,1] is a probability measure.*

Definition 3
A partition ξ of the measure space (Ω, ***B****, μ) is a disjoint collection $\xi = \{B_1, \ldots, B_k\}$ of measurable sets whose union is all of Ω.*

Definition 4
Let $\xi = \{B_1, \ldots, B_k\}$ be a partition of Ω, the degree of visibility in a supply chain in V= (SC, Ω, ***B****, μ) can be calculated using entropy*

$$Deg(V) = H(\xi) = -r_V \sum_{q=1}^{k} \mu(B_q) \log \mu(B_q) \quad (1)$$

where r_V = 1/log(|A|×|I|) is a visibility constant.

Definition 4 provides a basic method for computing visibility entropy. Let $\xi_{a_i} = \{B_1, \ldots, B_p\}$ be a partition of Ω_{a_i}, which is a set of VCs whose assessor is a_i. The degree of actor a_i can be computed in Definition 5.

Definition 5
*The degree of visibility of an actor in a supply chain in V= (SC, Ω, **B**, μ) can be calculated using entropy*
$$Deg(a_i|V) = H(\xi_{a_i}) = -r_V \sum_{q=1}^{p} \mu(B_q)\log\mu(B_q) \quad (2)$$
Let $\xi' = \{B_1,...,B_p\}$ be a partition of a set of Ω', which is a set of VCs whose assessors are in a set of actors A'. The degree of the set of actors can be computed in the following Theorem.

Definition 6
*The degree of visibility of a set of actors A' in a supply chain in V= (SC, Ω, **B**, μ) can be calculated using entropy* $Deg(A'|V) = H(\xi') = -r_V \sum_{q=1}^{p} \mu(B_q)\log\mu(B_q)$ (3)
Definition 7
ξ = {B$_1$,…,B$_k$} is a simple partition, if $|B_j|$ = 1 and $\mu(B_j) = \mu(B_q)$, for any *j, p = 1,...,k*.

If ξ = {B$_1$,…,B$_k$} is a simple partition, the formula in Definition 4 can be further simplified as follows.

Theorem 1
*Let ξ = {B$_1$,…,B$_k$} be a simple partition, the degree of visibility for a supply chain in V= (SC, Ω, **B**, μ) can be calculated by*
$$Deg(V) = H(\xi) = r_V \log(k) \quad (4)$$
where $k = |\xi|$.

Proof: Let ξ = {B$_1$,…,B$_k$}, | B$_j$| = 1, where *j= 1,..,k*. Thus, p_j=1/k and $k = |\xi|$. From Definition 4,
$$H(\xi) = -r_V \sum_{q=1}^{k} \mu(B_q)\log\mu(B_q)$$
$$= -r_V \sum_{q=1}^{k} p_q \log p_q = -r_V \sum_{q=1}^{k} \frac{1}{k}\log(\frac{1}{k}) = r_V \log(k)$$
In the same way, we can prove the following two theorems.

Theorem 2
*Let $\xi_{a_i} = \{B_1,...,B_k\}$ be a simple partition, the degree of visibility for an actor in V= (SC, Ω, **B**, μ) can be calculated by*
$$Deg(a_i|V) = H(\xi_{a_i}) = r_V \log(k) \quad (5)$$
where ξ_{a_i} is a partition of $\Omega_{a_i} \subseteq \Omega$, which is a set of VCs whose assessor is a_i, $k = |\xi_{a_i}|$.

Theorem 3
*Let $\xi' = \{B_1,...,B_k\}$ be a simple partition, the degree of SCV of a set of actors A' in V= (SC, Ω, **B**, μ) can be calculated using entropy*
$$Deg(A'|V) = H(\xi') = r_V \log(k) \quad (6)$$
where ξ' be a partition of a set of $\Omega' \subseteq \Omega$, which is a set of VCs whose assessors are in a set of actors A', $k = |\xi'|$.

EXPERIMENTAL RESULTS
To demonstrate the viability of the theoretical model, we conduct an experimental validation through investigating SCV in an aerospace supply chain. The supply chain consists of an OEM (***a₁***) who assembles components using parts provided by two tier 1 suppliers (***a₂*** and ***a₃***), and three tier 2 suppliers (***a₄***, ***a₅*** and ***a₆***). To simplify, we focus on only two types of information items, monthly inventory level and weekly inventory level for the parts provided by the suppliers at different locations. As shown in Fig. 1, ***i₁*** denotes the monthly inventory level at the manufacturer's warehouse, ***i₂*** denotes the monthly inventory level at a wholesaler, and ***i₃*** denotes the monthly inventory level at the other wholesaler, etc. In this supply chain, tier 1 supplier ***a₂*** implemented the latest IT systems including ERP and VMI systems so that it has better SCV, whereas tier 1 supplier ***a₃*** was based on traditional manual processes without proper IT systems for SCV before supplier ***a₃*** upgraded its IT systems. Using the methods presented in previous section, the degrees of inventory visibility for the supply chain can be calculated using eqn (5) in the following.

$$Deg(a_1 \mid V) = H(\xi_{a_1}) = k_V \times \log(|\xi_{a_1}|) = k_V \times \log(9) = 0.5138$$

$$Deg(a_2 \mid V) = H(\xi_{a_2}) = k_V \times \log(6) = 0.4190$$

$$Deg(a_3 \mid V) = H(\xi_{a_3}) = k_V \times \log(4) = 0.3242$$

$$Deg(a_4 \mid V) = H(\xi_{a_4}) = k_V \times \log(2) = 0.1621$$

$$Deg(a_5 \mid V) = H(\xi_{a_5}) = k_V \times \log(2) = 0.1621$$

$$Deg(a_6 \mid V) = H(\xi_{a_6}) = k_V \times \log(2) = 0.1621$$

where k_v= 1/log(72).

Compared to supplier $\boldsymbol{a_2}$, $\boldsymbol{a}_3$ has less capability to access and provide information. The visibilities for the OEM, Tier 1 suppliers, and Tier 2 suppliers can be calculated as 0.5138, 0.5184, and 0.4190, respectively. After supplier $\boldsymbol{a_3}$ realises its disadvantage in the supply chain, it upgrades its IT system and the visibility of the supply chain is improved. The IT systems have integrated the OEM and suppliers so that they can share SCV information. After integrating the IT systems, the overall visibility of the supply chain is improved significantly. The degree of visibility of the supply chain has increased from 0.7527 to 0.8626. Table 1 summarises the details of final SCV assessment.

	Visibility		Change
	Before	After	
a_1	0.5132	0.5810	+0.0673
a_2	0.4190	0.5810	+0.1621
a_3	0.3242	0.5810	+0.2569
a_4	0.1621	0.1621	0.0000
a_5	0.1621	0.1621	0.0000
a_6	0.1621	0.1621	0.0000
OEM	0.5132	0.5810	+0.0673
Tier 1 Supplier	0.5384	0.7431	+0.2047
Tier 2 Supplier	0.4190	0.4190	0.0000
Supply Chain	0.7527	0.8626	+0.1099

Table 1: Summary of assessment of SCV for aerospace supply chain

CONCLUSION

This paper presents a novel method based on entropy to objectively assess SCV to overcome the bias of current subjective methods based on surveys. The assessment method contributes to both research and practice for a better understanding of SCV. The experimental result for a study of an aerospace supply chain verifies the viability of the assessment method. The method can help companies to select suppliers for collaboration based on the assessment of visibility of the suppliers and to assess SCV for supply chain performance improvement.

Several future research areas are possible. First, more empirical research need to be conducted to support the assessment method. Second, the analysis of the economic impact of the mathematical model presented is worth pursuing to aid better decision making. Last, the quantitative analysis of the impact of SCV on supply chain risk is another potential research topic as many companies are trying to implement visibility solutions to improve supply chain risk management given the example of the recent

Toyota recall incident which revealed that 90 percent of firms do not conduct a risk assessment when outsourcing production.

REFERENCES

Bailey, K. and M. Francis (2008). "Managing information flows for improved value chain performance." International Journal of Production Economics **111**(1): 2-12.

Barratt, M. and A. Oke (2007). "Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective." Journal of Operations Management **25**(6): 1217-1233.

Bartlett, P. A., D. M. Julien, et al. (2007). "Improving supply chain performance through improved visibility." The International Journal of Logistics Management **18**(2): 294-313.

Berry, D. and M. M. Naim (1996). "Quantifying the relative improvements of redesign strategies in a P.C. supply chain." International Journal of Production Economics **46-47**: 181-196.

Bottani, E. and A. Rizzi (2008). "Economical assessment of the impact of RFID technology and EPC system on the fast-moving consumer goods supply chain." International Journal of Production Economics **112**(2): 548-569.

Daugherty, P. J., R. G. Richey, et al. (2006). "Is collaboration paying off for firms?" Business Horizons **49**(1): 61-70.

Doerr, K. H., W. R. Gates, et al. (2006). "A hybrid approach to the valuation of RFID/MEMS technology applied to ordnance inventory." International Journal of Production Economics **103**(2): 726-741.

Enslow, B. (2006). Global supply chain benchmark report: Industry priorities for visibility, B2B collaboration, trade compliance, and risk management, Aberdeen Group.

Fleisch, E. and C. Tellkamp (2005). "Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain." International Journal of Production Economics **95**(3): 373-385.

Fosso Wamba, S., L. A. Lefebvre, et al. (2008). "Exploring the impact of RFID technology and the EPC network on mobile B2B eCommerce: A case study in the retail industry." International Journal of Production Economics **112**(2): 614-629.

Francis, V. (2008). "Supply chain visibility: lost in translation?" Supply Chain Management: An International Journal **13**(3): 180-184.

Freire, E., L. J. Michael, et al. (1994). [23] Statistical thermodynamic analysis of differential scanning calorimetry data: Structural deconvolution of heat capacity function of proteins. Methods in Enzymology, Academic Press. **240:** 502-530.

Goh, M., R. De Souza, et al. (2009). Supply Chain Visibility: A decision making perspective. Industrial Electronics and Applications, 2009. ICIEA 2009. 4th IEEE Conference on.

Gumrukcu, S., M. D. Rossetti, et al. (2008). "Quantifying the costs of cycle counting in a two-echelon supply chain with multiple items." International Journal of Production Economics **116**(2): 263-274.

Hsiao-Lan, W. and E. T. G. Wang (2007). Creating Strategic Value from Supply Chain Visibility- the Dynamic Capabilities View. System Sciences, HICSS 2007. 40th Annual Hawaii International Conference on.

Huo, Y.-f. and X.-y. Jiang (2007). Research on CPFR and Warehousing Management: A Method to Enhance Supply Chain Visibility. Wireless Communications, Networking and Mobile Computing, WiCom 2007. International Conference on.

IBM (2009). The Smarter Supply Chain of The Future: Global Chief Supply Chain Officer Study.

Jorgensen, S. E. and Y. M. Svirezhev (2004). Entropy, probability and information. Towards a Thermodynamic Theory for Ecological Systems. Oxford, Pergamon: 69-93.

Kaipia, R. and H. Hartiala (2006). "How to benefit from Visibility in Supply Chains." InternationalJournal of AgileManufacturing **9**(1): 9-18.

Landers, T. L., M. H. Cole, et al. (2000). "The virtual warehousing concept." Transportation Research Part E: Logistics and Transportation Review **36**(2): 115-126.

Law, C. C. H. and E. W. T. Ngai (2007). "ERP systems adoption: An exploratory study of the organizational factors and impacts of ERP success." Information & Management **44**(4): 418-432.
Lei, Z., B. Chen, et al. (2005). Thermodynamic fundamentals. Special Distillation Processes. Amsterdam, Elsevier Science**:** 1-58.
McCrea, B. (2005). "EMS completes the visibility picture." Logistics Management **44**(6): 57-61.
Melski, A., J. Muller, et al. (2008). Improving supply chain visibility through RFID data. Data Engineering Workshop, 2008. ICDEW 2008. IEEE 24th International Conference on.
O'Neill, L. and B. Newton (2004). "Connecting to the vision [next generation intelligence]." Manufacturing Engineer **83**(2): 20-23.
Paulus, D. M., R. A. Gaggioli, et al. (2005). Some Observations of Entropy Extrema in Physical Processes. Variational and Extremum Principles in Macroscopic Systems. Oxford, Elsevier**:** 413-438.
Rao, S. (2004). "Supply Chain Management: Strengthening the Weakest Link!", from http://www.frost.com/prod/servlet/market-insight-top.pag?docid=10709461.
Rekik, Y., E. Sahin, et al. (2009). "Inventory inaccuracy in retail stores due to theft: An analysis of the benefits of RFID." International Journal of Production Economics **In Press, Corrected Proof**(1): 189-198.
Sahin, E., J. Buzacott, et al. (2008). "Analysis of a newsvendor which has errors in inventory data records." European Journal of Operational Research **188**(2): 370-389.
Sahin, E. and Y. Dallery (2009). "Assessing the impact of inventory inaccuracies within a Newsvendor framework." European Journal of Operational Research **197**(3): 1108-1118.
Shannon, C. E. and W. Weaver (1998). The Mathematical Theory of Communication University of Illinois Press.
Szmerekovsky, J. G. and J. Zhang (2008). "Coordination and adoption of item-level RFID with vendor managed inventory." International Journal of Production Economics **114**(1): 388-398.
Tohamy, N., L. M. Orlov, et al. (2003). Supply chain visibility defined, Forrester Research, Cambridge, MA.
Uçkun, C., F. Karaesmen, et al. (2008). "Investment in improved inventory accuracy in a decentralized supply chain." International Journal of Production Economics **113**(2): 546-566.
Ustundag, A. and M. Tanyas (2009). "The impacts of Radio Frequency Identification (RFID) technology on supply chain costs." Transportation Research Part E: Logistics and Transportation Review **45**(1): 29-28.
Vitasek, K. (2006). "Supply chain and logistics terms and glossary." from http://www.lehigh.edu/~inchain/glossary/Glossary-OCT06-2.pdf.
Wright, K. M. and D. N. Rutledge (1996). Chapter 2 Maximum entropy methods in NMR data processing. Data Handling in Science and Technology, Elsevier. **Volume 18:** 25-43.
Wu, N. C., M. A. Nystrom, et al. (2006). "Challenges to global RFID adoption." Technovation **26**(12): 1317-1323.
Zhang, N., W. He, et al. (2008). Address supply chain visibility from knowledge management perspective. Industrial Informatics, INDIN 2008. 6th IEEE International Conference on.
Zhou, W. (2009). "RFID and item-level information visibility." European Journal of Operational Research **198**(1): 252-258.

TOTAL QUALITY MANAGEMENT AND CONTINUOUS PROCESS IMPROVEMENT OF ENGINEERING PROJECTS: A PHENOMENOGRAPHICAL STUDY OF A SEMICONDUCTOR MANUFACTURING FIRM IN MALAYSIA

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ABSTRACT
Due to the growing importance placed on total quality management (TQM) practices in the manufacturing sector over the past few years, this paper analyses the practice of TQM in a semiconductor manufacturing firm in Melaka using a phenomenographical approach based on the experiences of the project leaders to determine how TQM contributes engineering performance. This study therefore provides an initial understanding of how the managerial, human, technical and contextual aspects of TQM play a role in engineering project performance based on the experiences and thoughts of engineering project leaders who are the nexus between the management team and workers that has not received adequate coverage in the engineering management and supply chain management literature. Managerial aspects of TQM is found to be the key factor in the determination of effective TQM practices and enhanced engineering project performance.

INTRODUCTION
Engineering project work requires the capability to efficiently manage in accordance with ‘‘hard’’ and predictable processes that prescribe the work as it is planned to be done, while at the same time being compatible with the ‘‘soft’’ and unpredictable processes that are often in contradiction with the former (Zika-Viktorsson & Ritzen, 2005, p. 198). Efforts to develop work methods, processes and routines have always been a part of work life and today, it is possible to discern an emphasis on co-worker participation in activities, aimed at the continuous improvement of work methods and work design, as a means towards development, learning and better goal fulfillment in organizations (Zika-Viktorsson & Ingelgard, 2006, p. 103). It is undeniable that TQM has had a profound and unparalleled impact on modern business history and landscape (Prajogo & Hong, 2008).

However, the development of TQM practices should provide useful measures for investigating the relationship between TQM practices and job satisfaction particularly in relation to the major Malaysian semiconductor organization where studies are yet to be conducted (Ooi, Nooh Abu Bakar, & Arumugam, 2007). There is still a lack of studies on the link between TQM practices and affective commitment within the context of the Malaysian semiconductor manufacturing industry (Ooi, Mohammad Samaun Safa, & Arumugam, 2006). Based on the extant literature, the perspectives of the people involved in TQM have more often than not been sidelined. As such this study aims to obtain a better understanding of the experiences and thoughts of engineering project leaders who are the nexus between the management team and workers that has not received adequate coverage in the engineering management and supply chain management literature. Hence, the research question identified for this study is:

> ‘***How do the human, managerial, technical and contextual aspects of a semiconductor manufacturing firm as experienced by engineering project leaders affect its TQM effectiveness and engineering performance?’.***

LITERATURE REVIEW

Total Quality Management (TQM)

TQM refers to structures of applications with organized or methodical outcome on organization practices and effectiveness (Martınez-Costa, Martınez-Lorente, & Choi, 2008). In addition to that, Kaynak (2003) suggests that it refers to comprehensive organizational philosophies striving in continual and functional development that is realized by quality concepts employed commencing at resource acquisitions right up toward consumer relations subsequent to retails. According to Forza and Filippini (1998) the TQM concept is characterized with directions toward value that aids in preventing crisis as well as producing continual enhancement in current conditions. Fuentes-Fuentes, Albacete-Saez and Llorens-Montes (2004, p. 426) suggest that the limitations of surroundings toward quality as well as results in it affect an organization's efficacy. Specifically, they elaborate that this representation consists of variables of environment dimensions, core TQM values and organizational performance.

A firm that plans to employ TQM as a rudimentary approach for its actions must bear in mind that the various components of the environment possess attributes that can possibly be damaging to accomplish its objectives (Fuentes-Fuentes et al., 2004). Fuentes-Fuentes et al. (2004) expostulate that environment-organization interfaces cause the divergences in the outcomes reached by TQM implementation will also be stipulated by the environment factor. Prajogo and Hong (2008) advocate that in spite of plentiful research concerning links connecting quality with organizational performances amid immense acceptances in quality philosophies, there is but little thorough experiential research regarding associations connecting quality along with research and development performances. While there is no doubt about subjects concerning TQM as well as innovativeness being handled comprehensively at numerous angles, investigations regarding association linking these notions prove to be minimal (Perdomo-Ortiz, Gonzalez-Benito, & Galende, 2006). According to Prajogo and Hong (2008) employing total quality management at research and development contexts becomes taxing in contrast with additional organizational implementations because research and development functions are mainly dependable on innovativeness.

Product/Process management

Jung and Wang (2006, p. 721) suggest that product plus process managing are together by existing as technological characteristics in quality management. For many manufacturing processes, high product customization means lower volumes for many of the steps in the process and if customization, top quality and product variety are strongly emphasized, the likely result is lower volume for any particular step in the manufacturing process (Krajewski, Ritzman, & Malhotra, 2007). Ahire and Dreyfus (2000) concur that the similar workers that join sophisticated inventive managerial undertakings implement TQM rudiments. They conclude that the employees' familiarity, know-how as well as characters concerning joint effort, collaboration as well as consumer emphasis ought to overflow towards continuing endeavors in following along with enhancing TQM in industrial practices.

Product and process management symbolizes managing application sequences, which allocate in favor of operational performances in different factors along with constituting technical approaches for analysis and investigations (Fuentes-Fuentes, Montes, & Fernández, 2006). Prajogo and Hong (2008) suggest that quality management has major influences in innovativeness as well as technical performance, whereby enhancing functionalities and technical performance in current inventions are just as important as NPD.

Prajogo and Sohal (2006) consider technical performance to merely indirectly affect NPD performances via innovations in processes, whereby the tactic for practising product innovation or expanding product diversity can lead to embracing of process innovation due to the distinctiveness of the products that are coupled with certain production process characteristics. In TQM projects, products and processes will advance the design away from exceedingly shallow emphasis on industrial characteristics toward usability engineering (Ebert & Man, 2008). Perdomo-Ortiz et al. (2006) posit that designing products searches for technical performance through obeying customer specifications. Therefore, they abbreviate that innovativeness is motivated followed by their finding in emphasizing on technical performance compared to cost assists in building business innovation capability and integrates diverse functions for NPD. However, even as quality management supports magnitudes in innovativeness, approaches are responsive compared to enthusiastic, making quality management supporting NPD merely if unequivocal demands exist (Prajogo & Sohal, 2001).

Continuous improvement

Among some of the areas of foci in modern quality research and practice, continuous improvement is one that enterprises must emphasize on in order to develop quality products along with its service continually as well as reduce costs to create customer satisfaction (Chang, 2009). Continuous improvement focuses on a product's customer service as well as centralized production process, creating achievement levels that constantly increases for performing current tasks correctly along with improving them in the future (Chin, Tummala, & Chan, 2002, p. 215). According to Abrunhosa and Sa (2008, p. 221) continual improvements require organizational cultures which continuously give confidence in participants in innovating, minimizing panic along with providing themselves by means of effective tools.

Continuous improvement projects are internal to an organization and result in process changes, where the customers involved are normally internal managers or a group of managers who wish to change the manner in which current operations occur (Cleland & Ireland, 2007). Fuentes-Fuentes et al. (2006) suggest that in companies mainly leaning towards selling, proportions in collaboration, continual enhancement along with consumer emphasis consent larger boosts on performances in operation. In addition to that, specialized task managing skills aspire in continual enhancement in projects so that lasting business objectives as well as undeviating performance are attained (Ayas, 1996).

However, Abrunhosa and Sa (2008) argue that although enhancement appears as we experience slip-ups, implement counteractive measures as well as try innovative stuff, it often becomes a challenge for enhancement prospects in continually being recognized as well as evaluated by outside along with inside consumers in measuring development in the direction of targets. Fuentes-Fuentes et al. (2004) also point out that continual enhancement cannot directly mediate with improvements in products as well as services due to a relationship presence connecting it with added measurements in quality management, specifically such as consumer emphasis along with collaboration. In summary, the research gaps concerning continuous improvement in engineering project performance are whether or not it is continuously identified and evaluated by customers and whether or not it is an element in TQM that contributes directly to project performance (Abrunhosa & Sa, 2008; Fuentes-Fuentes et al., 2004).

RESEARCH METHOD

Based on a phenomenographical analysis of interviews with engineering project leaders of a large semiconductor manufacturing firm in Melaka which has implemented TQM for over 5 years, we identify different layers of understanding by focusing on the referential objects and the structural components of TQM and its role on engineering performance. Due to the abundance of quantitative and grounded theory approaches to the study of manufacturing processes, this study employs the use of phenomenography to canvass the alternative views or the structures of individual thought-models of project leaders (Marton & Booth, 1997). This is because phenomenography allows for the creation of a hierarchical structure of thought models due to the variation in the richness and versatility of some thought-models uncovered during the interview process.

Phenomenography in essence is about individual meaning construction, which results in a conception referring to conceiving and understanding something (Marton, 1986). Akerlind (2005) explains that this would therefore enrich our understanding of the phenomena which has been more often than not aggregated in the form of surveys and mean averages, therefore neglecting the voice of the individual at the ground.

Guided by an interview protocol, the researchers interviewed a total of eight experienced project leaders for approximately 45–90 minutes each on how TQM influences the manufacturing firm's engineering project performance based on their individual project management experiences. These respondents were selected for the interview based on their project leadership experience and tenure in the firm. All respondents were assured of the confidentiality and anonymity of their responses and the intent of the interview and research. The interview session was recorded using a voice recorder and later transcribed for analysis using NVIVO 8, a qualitative data analysis application to identify the emerging codes and themes. Based on this analysis, the findings of the study are presented in the next section.

FINDINGS

A total of 8 semi-structured interviews were conducted with project leaders such as project managers, project engineers, development engineers, quality engineers and many more. The interviews took approximately 45 to 90 minutes per session. The total time to gather all responses was approximately 2 weeks. The following sections explain the results of these preliminary survey interviews according to the elements of TQM. To ensure the anonymity of the interview participants and to facilitate data analysis, each interviewee is assigned an identifier in a form of nicknames. Details of the interview participants are outlined in Table 1.

Table 1 Details of interview participants

Identifier	Position title	Sex	Years of work experience	Years of experience as project leader
Alvin	Production Manager	Male	12	2
Anna	Senior Manufacturing Engineer	Female	8	2
Charles	Manufacturing Manager	Male	13	8
Harry	Project Manager	Male	20	11
Kathy	TQM Executive	Female	20	12
Kelly	Process Engineer	Female	4	1
Raymond	Engineering Sample Engineer	Male	3	3
Teresa	Quality Engineer	Female	5	3

(Source: developed for this study)

Human aspects

In terms of human aspects, employee empowerment in decision making is proven strong in this firm especially in their self managing team culture whereby employees are allowed to go on leave provided they arrange their coverage (Charles & Harry). Alvin suggests that '*it is through union that employees are given the opportunity to make strong and effective decisions which are able to make a difference*'. This is made possible in this firm due to its relatively competent and highly qualified pool of human capital it has and its gradual move towards a research and development-oriented focus over the past few years.

In more engineering related areas, Anna states that '*process engineers are given the decision power on whether to release a low yield lot or not and also to perform process changes*'. Harry explains that '*due to the criticality of certain projects, employees are* *given the opportunity to enforce their decisions but not without any guidelines or advice involved'*. Raymond and Teresa reiterate that *'a certain limit or control is still needed to be instigated amongst them so that they do not accidentally make the wrong decision that can jeopardize the firm's image'*. However, among the more inexperienced project leaders with fewer than 5 years of experience, they do not seem to take on their self-managing role and would normally consult their supervisors before making any important decision (Kelly, Raymond & Teresa). Raymond and Kelly believe that *'their decision making power is limited to either agreeing or disagreeing with what their top management decides'*.

As for their teamwork, Alvin and Charles relate that *'the firm has been standing strong for 35 years without any barriers and teamwork everywhere'*. This is important in their work culture as it reflects personal commitment towards customer satisfaction, breakthrough ideas through innovation, working together with one another as partners and creating values for customers and society (Charles). However, out of the 8 interviewees, Kelly, Raymond and Teresa believe that *'barriers still exist among departments and there is still lack of unity in the firm'*. Raymond points out that *'although these barriers exist, they still can be resolved if parties come to consensus in a win-win opportunity kind of situation'*. As such, organizational incentives that provides for 'win-win opportunities' do take precedence over personal motives, steering employees to work together even if they may have issues with other colleagues.

Managerial aspects
Based on the interviews conducted, the managerial aspect was found to play an important role in the semiconductor manufacturing firm's performance. The top management strongly supports the company's vision and direction towards quality improvement (Alvin). Alvin and Charles explain that *'it is a necessity in the firm for every single employee, from top management to the shop floor, to be committed to quality'*. This was well demonstrated by a program named Zero Defect which was launched in 2005 to establish a philosophy of commitment to quality amongst all employees and has since then, become a part of the firm's yearly program up till today (Alvin).

In addition to that, Harry believes that *'the firm also has a relatively strong vision and strategy, striving to be the best backend manufacturing plant in the whole region'*. Harry further explains that *'in order to fulfill this, the firm strives for excellence in their people'*. Kelly, Raymond and Teresa agree that *'a firm without vision and strategy is a firm without any direction and will most likely fall'*. The firm's vision and strategy are important as they provide a common thread amongst the diversity to give them a sense of common identity and belonging in order to reach a common goal (Kathy). Anna and Raymond explain that *'the vision and strategy of their firm is strongly linked with the quality fundamentals of the firm, which focuses mainly on zero defects'*.

Furthermore, management does not restrict the opportunities of employees to assist in implementing changes (Alvin). According to Harry, *'opportunity is given to everyone and any new ideas and new opportunities, if can be implemented, are always welcomed'*. One of the prominent examples is the YIP program or better known as Your Idea Pays program whereby employees are provided the opportunity to contribute their insightful ideas to the firm to be implemented and are rewarded for it (Harry & Kathy). Some other examples of these opportunities given were the abundant platforms such as quality improvement programs, Energy Management program, Material Review Board, Global Change Management and Product Change Notifications (Kathy).

Technical aspects
In terms of technical aspects, benchmarks and quality levels are set by the organisation for its employees apart from the use of well-known process and quality improvement methods. Employees are given recognition when their products and processes meet

quality standards through schemes and programs like quality incentive scheme, 'Your Idea Pays' program, Business Excellence Award and Monetary Award for outstanding performance (Alvin, Charles, Harry and Anna). According to Charles, *'design of processes in the plant is also 'fool-proof' (preventive-oriented'*. He further explains that *'they are based on 'poke-yoke' (defect proof) concepts and are also patented'*. The design of processes are also further ensured with additional control measures and contingency programs (Anna). However, in terms of recognition given, Anna indicates that *'sometimes it may depend on whether the particular job description or project ownership belongs to them or not'*. Also, Harry believe that *'there is still room for improvement in terms of the design of processes'*. Kathy and Charles do agree that *'not all designs of processes are completely 'fool-proof''*. Kelly and Raymond are not even sure of whether their designs are preventive-oriented or not.

In demonstrating continuous improvement, Alvin states that *'the firm has been winning many awards for the past five years in improving products, services and processes'*. The company has even attained recognition from the government as well (Charles). During the last ten years, this firm has received the Prime Minister Quality Award, National Productivity Corporation (NPC) Productivity Award and the Quality Management Excellence Award – the triple crown of the Productivity and Quality Awards – from the Prime Minister (Harry & Kathy). Among the other recent ones were Best European Supply Chain Award and best supplier award from LG. Other accomplishments include good feedback from customer audits and other audit organizations (Alvin & Anna). Hence, the application and adoption of well-established methods, practices and tools have allowed the organisation to perform relatively well in terms of improved engineering performance over the past few years.

Contextual aspects

In the contextual aspects, Alvin and Harry state that *'everyone has their own targets to achieve'*. Managers and suppliers in diverse sections normally operate autonomously towards achieving the section's individual targets whereby they have their own individual prioritized targets to work upon (Harry). Despite this, the teamwork is still strong among employees within those departments (Alvin). Kathy agrees that *'teamwork is a good thing for the firm's development'*. Employees in the firm are also not afraid to voice their opinions and ideas since the culture there encourages them to do so through Your Idea Pays program where employees make suggestions and implement them on the production floor and any queries are answered during the mass communication platform (Kelly & Teresa). Anna believes that *'the mass communication held in the firm is very important as it gives all employees a chance to voice out their queries to the top management'*. The international roots of this organisation and the egalitarian nature of work and performance measurement create a conducive work environment that cultivates excellence and quality attainment.

By winning many quality based awards, this company has demonstrated its focus and commitment to continuous improvement in their products and processes. This is clearly seen as projects that largely concern themselves with improving manufacturing yields and throughput within the broad scope of the existing technology (Sen & Egelhoff, 2000).

Table 2 provides a summary of the interview findings based on the TQM aspects involved with relevance to the literature review.

Table 4.2 Summary of interview findings and literature

TQM aspects	Findings	Related literature
Managerial	Total commitment and management support is essential for the success of TQM.	(Reed et al., 2000), (Fazli Idris & Khairul Anuar Mohd Ali, 2008)

Human	The firm allows employees to make decisions and provide employee empowerment.	(Kaynak, 2003)
Technical	The firm focuses on developing and manufacturing existing products. By winning many quality based awards, this firm demonstrated focus and commitment to continuous improvement.	(Prajogo & Hong, 2008), (Sen & Egelhoff, 2000)
Contextual	The firm's culture allows employees to voice out opinions for improved learning capabilities and opportunities.	(Fuentes-Fuentes et al., 2006)

(Source: developed for this study)

CONCLUSIONS

Based on the interviews conducted and analyses conducted, it is found that all four aspects do influence the organisation's performance. However, it can be observed that the organisation's managerial aspect is the most influential variable in improving engineering project performance through TQM. This finding that supports the assertion that total commitment and management support is essential for the success of TQM implementation is consistent with that of the study from Reed et al. (2000) and Fazli Idris and Khairul Anuar Mohd Ali (2008). The company's policy in meeting and exceeding its' customer expectations is consistent with the findings of Jung and Wang (2006). It was found that the company portrays outstanding achievements in terms of their product and process management by receiving many awards and recognitions. Quality management has major influences in innovativeness as well as technical performance, whereby enhancing functionalities and technical performance in current inventions are just as important as NPD. (Prajogo & Hong, 2008). This is clearly true for this particular company as it focuses on developing and manufacturing existing products. Besides that, Ahire and Dreyfus (2000) concur that the similar workers that join sophisticated inventive managerial undertakings implement TQM rudiments. In order for employees in this firm to engage in the improvement of product quality, their design of processes are required to be "fool proof" and based on poke-yoke concepts whereby quality standards and requirements are kept at a stringent level of approval. As such, organisations need to pay attention to the managerial, technical, human and contextual aspects in order to ensure effective engineering performance when implementing quality improvement programmes such as TQM as evidenced by this study.

REFERENCES

Abrunhosa, A., & Sa, P. M. E. (2008). Are TQM principles supporting innovation in the Portuguese footwear industry? *Technovation, 28*(4), 208-221.

Ahire, S. L., & Dreyfus, P. (2000). The impact of design management and process management on quality: an empirical investigation. *Journal of Operations Management, 18*(5), 549-575.

Akerlind. G. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research and Development, 24*(4), 321-334.

Ayas, K. (1996). Professional project management: A shift towards learning and a knowledge creating structure. *International Journal of Project Management, 14*(3), 131-136.

Chang, G. (2009). Total Quality Management in Supply Chain. *International Business Research, 2*(2), 82-85.

Chin, K. S., Tummala, V. M. R., & Chan, K. M. (2002). Quality management practices based on seven core elements in Hong Kong manufacturing industries. *Technovation, 22*(4), 213-230.

Cleland, D. I., & Ireland, L. R. (2007). *Project Management: Strategic Design and Implementation* (5th ed.). Boston: McGraw-Hill.

Ebert, C., & Man, J. D. (2008). Effectively utilizing project, product and process knowledge. *Information and Software Technology, 50*(6), 579-594.

Fazli Idris, & Khairul Anuar Mohd Ali. (2008). The impacts of leadership style and best practices on company performances: Empirical evidence from business firms in Malaysia. *Total Quality Management & Business Excellence, 19*(1-2), 163-171.

Forza, C., & Filippini, R. (1998). TQM impact on quality conformance and customer satisfaction: A causal model. *International Journal of Production Economics, 55*, 1-20.
Fuentes-Fuentes, M. M., Albacete-Saez, C. A., & Llorens-Montes, F. J. (2004). The impact of environmental characteristics on TQM principles and organizational performance. *The International Journal of Management Science, 32*(6), 425-442.
Fuentes-Fuentes, M. M., Montes, F. J. L., & Fernández, L. M. (2006). Total Quality Management, Strategic Orientation and Organizational Performance: the Case of Spanish Companies. *Total Quality Management & Business Excellence, 17*(3), 303-323.
Goetsch, D. L., & Davis, S. B. (2006). *Quality Management: Introduction to Total Quality Management for Production, Processing, and Services* (5 ed.). New Jersey: Pearson Education International.
Jung, J. Y., & Wang, Y. J. (2006). Relationship between total quality management (TQM) and continuous improvement of international project management (CIIPM). *Technovation, 26*(5-6), 716–722.
Kaynak, H. (2003). The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management, 21*(4), 405-435.
Krajewski, L. J., Ritzman, L. P., & Malhotra, M. K. (2007). *Operations Management: Processes and Value Chains* (8th ed.). New Jersey: Pearson Education Inc.
Martınez-Costa, M., Martınez-Lorente, A. R., & Choi, T. Y. (2008). Simultaneous consideration of TQM and ISO 9000 on performance and motivation: An empirical study of Spanish companies. *International Journal of Production Economics, 113*(1), 23-29.
Marton, F. (1986). A research approach investigating differenct understandings of reality. *Journal of Thought, 21*(2), 28-49.
Marton, F., & Booth, S. (1997). *Learning and Awareness*. New Jersey: Lawrence Erlbaum Associates Inc.
Ooi, K. B., Mohammad Samaun Safa, & Arumugam, V. (2006). TQM practices and affective commitment: a case of Malaysian semiconductor packaging organizations. *International Journal of Management and Entrepreneurship, 2*(1), 37-55.
Ooi, K. B., Nooh Abu Bakar, & Arumugam, V. (2007). Does TQM influence employees' job satisfaction? An empirical case analysis. *International Journal of Quality & Reliability Management, 24*(1), 62-77.
Perdomo-Ortiz, J., Gonzalez-Benito, J., & Galende, J. (2006). Total quality management as a forerunner of business innovation capability. *Technovation, 26*(10), 1170-1185.
Perdomo-Ortiz, J., Gonzalez-Benito, J., & Galende, J. (2006). Total quality management as a forerunner of business innovation capability. *Technovation, 26*, 1170-1185.
Prajogo, D. I., & Hong, S. W. (2008). The effect of TQM on performance in R&D environments: A perspective from South Korean firms. *Technovation, 28*(12), 855-863.
Prajogo, D. I., & Sohal, A. S. (2001). TQM and innovation: a literature review and research framework. *Technovation, 21*(9), 539-558.
Prajogo, D. I., & Sohal, A. S. (2006). The integration of TQM and technology/R&D management in determining quality and innovation performance. *The International Journal of Management Science, 34*(3), 296-312.
Reed, R., Lemak, D. J., & Mero, N. P. (2000). Total quality management and sustainable competitive advantage. *Journal of Quality Management, 5*(1), 5-26.
Sen, F. K., & Egelhoff, W. G. (2000). Innovative capabilities of a firm and the use of technical alliances. *IEEE Transactions on Engineering Management, 47*(2), 174-183.
Zika-Viktorsson, A., & Ingelgard, A. (2006). Reflecting activities in product developing teams: Conditions for improved project management processes. *Research in Engineering Design, 17*(2), 103-111.
Zika-Viktorsson, A., & Ritzen, S. (2005). Project competence in product development. *Research in Engineering Design, 15*(4), 193-200.

KEY FACTORS INFLUENCING THE EFFECTIVENESS AND EFFICIENCY OF SUPPLY CHAIN MANAGEMENT IN SMALL AND MEDIUM ENTERPRISES (SMES) IN MALAYSIA

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ABSTRACT
Over the last decades, Supply Chain Management (SCM) has become an important topic among manufacturing companies and academic researches to achieve a competitive advantage. In addition, getting better effectiveness and efficiency performance of SCM requires study on the main significant indicators which are affecting the performance of SCM. This paper discusses the key performance indicators (KPIs) that resulted from a questionnaire survey method and interview in SMEs of Malaysia, both quantitative and qualitative analysis has been done as well. The study revealed that on time delivery to the customer, product quality and service, and customer satisfaction in fulfilment of orders were the most important factors relative to successful supply chain processes. In addition, top management decision has been identified as the highest barrier to implementing supply chain management in the automotive sector. Also this paper would beneficial to all managers in implementing the SCM in Malaysia.

INTRODUCTION
Nowadays, companies need to collaborate through a network of manufacturing processes to provide the demand and desired products of consumer. Supply chain management perception initiated from the identification that the process of converting raw material into final goods and delivering those goods to end-user is becoming more and more complex. The supply chain (SC) is the main process function of companies to improve the customer service and demand. Alaa *et al*. (1997) asserted that, SC implementations cannot improve their efficiencies individually, because efficiency can be achieved through the integration of various supply chain practices. Therefore, the concept of SC emerged to explain the whole manufacturing stages from raw material procurement through product distribution to ultimate customer (Olugu and Wong, 2009). In addition, suppliers and operators should be sharing their goals and strategies of developing customer's satisfaction in product quality, cost, and service level (Chan F. and Qi. 2003). On the other hand, the uncertainty of requirement and shipment affect the steadiness of supply chain management (SCM) in achieving its main target. To resolve these issues and achieve their objectives, companies need to use performance measures (PM), because measuring became a major concern to operators and suppliers to understand the effectiveness of supplied material and production performance due to the fluctuation of high cost of distribution of materials and products. Meanwhile, many researchers developed PM approaches which can support day to day operations and provide information and details to managers, supervisors, and operators (Alaa *et al*., 2003, Koh L. and Gunasekaran A., 2007). Performance measurement approaches should improve managers' understanding of the process being evaluated (incomes-outcomes), behaviours throughout the organization, and present main details and knowledge to system operators and other stakeholders (Ross, and Droge C., 2004). However, with the level of competition in global market, companies are realizing the importance of improved effectiveness and efficiency of their processes to achieve customer satisfaction, the growth of market, product variety and flexibility. In addition, the increasing use of performance indicators to face these challenges in global market has become the main practice to understand the factors that affect the productivity, effectiveness, and efficiency of companies' supply chain management the most.

In order to offer an overall view of companies performance and to avoid local optimization, many researchers have tried to introduce methods and models to assess if the key performance indicators (KPIs) are meeting the criteria set by management of organization. Besides, understanding which factors are critical to the success of SCM is important to companies to face challenges such uncertainty, lead-time, process cost, and product variety etc. This study looks at various studies on supply chain performance measurement and pointed out the key factors that affect the effectiveness and efficiency of SCM in small and medium enterprises (SMEs) particularly the automotive industry.

The rest of the paper is organized as follows. Section 2 contains a literature review of existing studies which are related to our research. This is followed by section 3, which is the methodology that was used in this study. Analysis of data is presented in section 4. Finally the paper ends with discussion and concluding remarks for further study in section 4 and 5 respectively.

2.0 LITERATURE REVIEW

The literature review focuses on SCM and key performance factors/indicators, which have main impact on productivity, effectiveness, and efficiency of SCM. Key performance indicators are quantifiable measures, which reflect the critical success factors of an organization. They will change depending on the organization. In existing studies, the number of publication on performance measurement (PM) and supply chain management has increased radically. This is mainly due to fundamental changes in the business environment, and consumers have become more demanding (i.e. demands on features of product such as quality, safety, diversity, cost, and service). For example, Meindl (2004) pointed out that supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers and customers themselves. Also, supply chain is dynamic and involves the steady flow of information, product and finances among different phases.

2.1 Previous Studies

Kim S. (2006) asserted that, the improvement of SC functions can be done if the focus of SC practices shifted from functional and independent to general and integrative. Also, in order to continue to exist in the global competition and maintain long term advantages, further and further organizations have to adopt SCM. Green K. *et al.* (2008) figure out that, to compete at the supply chain level, manufacturers must adopt a supply chain management strategy, such as integration and coordination of key external processes; purchasing, selling, and logistics with SC partners. These strategy flows can be divided into several flows; product flow which includes the progress of products from suppliers to consumers, and customer returns or service desires as well; information flow which involves transmitting order updating the statues of delivery; and financial flow consists of credit terms, payment schedules, and consignment and identify ownership arrangements. Moreover, SCM strategy influences the logistics performance, and both of them positively impact marketing performance, which affects financial performance. According to Christopher (1992) companies realized that the real competition has become supply chain against supply chain rather than companies. Such as McCormack K. (2008) described, the concept maturity and improvement including SC processes, obtain from understanding that processes have improved stages that can be recognized, and controlled during time. Coşkun A. *et al*. (2008) highlight that mature of Total Quality Management (TQM) implementations in 1990s improved the adoption of non-financial measures by the companies, which made companies more focused in customer needs rather financial. In addition, directors recognized that in order to win competitive advantage they should be alert of the quality of the products and services. As well, defined the performance factors as long-term performance and short term performance are considered as important factors by managers, and long-term performance is the most important. Moreover, employee capabilities are found as important indicator effecting the performance satisfaction. Neely et al. (1995) defined PM as process of quantifying effectiveness and efficiency of action; otherwise you cannot manage what you cannot measure. From the management perception, performance measurement presents necessary information of management comment for decision makers and managers. It plays the significant roles of controlling performance, ornamental motivation, improving interactions, and detecting problems (Chan F. and Qi, 2003).

Cai J. *et al*. (2009) illustrated that Performance measurement is a main issue to improve supply chains' effectiveness and efficiency, and present a tool which can crucial KPIs accomplishment cost and strategies for decision makers in supply chain. Because of that, managers should identify the critical KPIs which need to be improved. As matter of fact, determination of priorities within a given set of KPIs has become a blockage for many corporations in their actions for improving their supply chain management (SCM). On the other hand, companies to achieve competitive advantages have to identify customer values and costs to customers as significant factors (Lai K.H *et al*., 2002). Gilmour P. (1999) has supported that, most of companies have become customer oriented; which reducing customer order time, improve the quality, and apply long-term strategies. This has shifted the focus logistics performance to a capability to add consumer value. Thakkar J. *et al,* (2009) identified supply chain management is perceived as a tool to ensure continuous improvement by many firms in the competitive market. Also they reported that, the number of factors such as increasing globalization, reduced barriers to international trade, improvement in information availability, and environmental concerns are attributed to the development of SCM.

Key performance indicators are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization. They differ depending on the organization business; service, manufacturing, or social. Whatever KPIs are they must reflect the organizations' subjects, to be the means of its achievement, and necessity to be measurable. Furthermore, to measure SC performance there are factors or variables which can be either physical variables such as inventory position or utilization rate, or economic variables such as profits and costs or revenues. Mentzer and konrad (1991) describe PM as effectiveness and efficiency in accomplishing a given duty in relation to how well an objective is met. The effectiveness known as level to which an activity fulfils its planned purpose or function (doing the right things). Lai K.H *et al,* (2002) illustrated that the effectiveness involved lead-time, stock-out probability, and fill rate in logistics and supply chain context. Many companies couldn't succeed in improving their supply chain potential, this is mainly because of their failure to improve measures and metrics needed to completely amalgamate their supply chain to take full advantage of effectiveness and efficiency (Gunasekaran *et al.,* 2004). Many experts and practitioners from supply chain strategy pointed out metrics for executives' consideration which integrate all dimensions of supply chain performance and respond to the factors: *total supply chain cost*: fulfilment cost per case order; *service level*: includes fill rate, operation performance, and service reliability; *asset management*: it focuses on the utilization of capital investments in facilities and equipment as well as working capital invested in inventory; *customer accommodation*: it aims to capture measurement of perfect orders, and customer satisfaction; *cash to cash cycle time*: it is time of a dollar collected from sales revenue; and *benchmarking*: it makes the management aware about the state of the art business practices (Jitesh Thakkar *et al.*, 2009). Furthermore, economic factor has become important the targets of companies. Many companies fail to develop a suitable SC that takes into account general economic conditions, currency value, inflation, and wages. For example, interest and currency exchange rates have an impact on the economy and influence the demand for the phenomena of products on the market, which that means no enough customers have money to buy (Gunasekaran and Ngai, 2005). Manufacturing productivity performance measurement is one factor which highly relevant to manufacturing company and productivity is one of the most significant standards by which to estimate the overall efficiency of manufacturing plant. However, productivity also can be affected by many factors as well, for instance; product volumes and lead time, people, capacity, inventory, cost and quality.

2.2 Malaysian SMEs

In Malaysia, SMEs continue to play a vital role in the country's industrialization programme, since they are the critical link between small and medium enterprises and large firms and multinational corporations. In recognition of SMEs' substantial contribution to the country's economy, MALAYSIA SME™ has been conceptualized to nurture further growth in this sector and by being the vehicle that bring together SMEs and the larger firms/multinational corporations (MALAYSIA SME™ Business Directory). Salman A. and Nelsone (2006) has discussed that, the SMEs is playing a critical role in Malaysian economy and are considered to be the backbone of industrial maturity in the country. Furthermore, small medium enterprises in Malaysia still face numerous global and domestic challenges in fulfilling economies of level and competing globally. The mainly challenges that facing SMEs are: low level of technological capabilities and limited skilled human capital resources, a low level of technology and ICT penetration, low level of research and development (R&D), a substantial orientation towards domestic markets, high level of international competition, and internal sourcing of funds. Although this challenges SMEs provide their importance to the economy as presented in Figure 1. According to SMIDEC, the target of raise their contribution to gross domestic product has improved from 32% in 2005 to 37% in 2010, exports from 19% to 22% and employment to 57% in 2010.

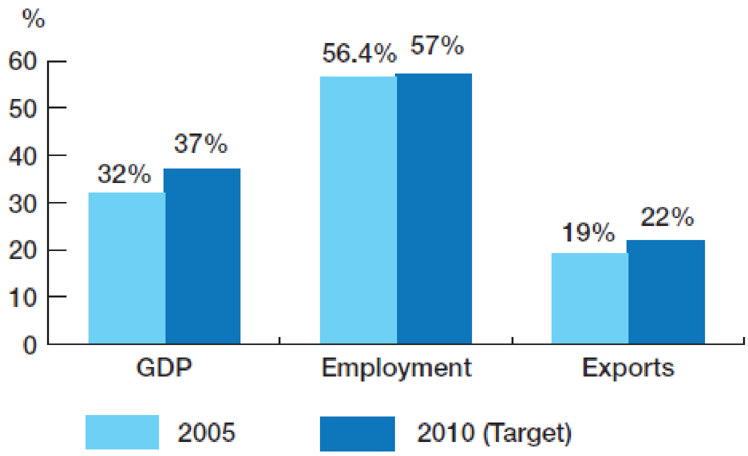

Figure 1: SMEs contribution to the economy

3. RESEARCH METHODOLOGY

Survey is considered as the most economical among methods available for data collection due to its ability in performing fast, efficient data collection and analysis. On the other hand, it also has weakness such as low response rate, quality of collected data, and accuracy of statistical methods used for data analysis. In general, quality of survey data collection depends on the sample design and size, techniques used, and how good survey questions measures (Deros B. *et al*., 2005).

The purpose of this study is to identify highly scored factors that impact supply chains practices. The study has identified 23 factors from previous research to provide appropriate key performance indicators for supply chain management implementation as presented in Table 1. The data were collected through questionnaires sent to supply chain managers, production managers, and top level executives in hundreds of manufacturing corporations among Malaysia's listed corporation. The questionnaires were distributed by individual visit, email, and posts. The main respondents were as listed above, but in their absence, response was requested from their assistants.

The questionnaire was divided into four sections exploring supply chain relationship, first section was factors affecting the performance of supply chain drivers, and how important they felt SCs and performance measurement indicators (PMIs) using seven points score ranging from "1" indicating least important and "7" indicating very important. These factors were summarized from previous studies, researches, and specialized books. Second section identified some basic information on supply chains drivers (supplying, manufacturing, inventory, distribution, information flow and cost). Third section comprised the PMIs (productivity, effectiveness, efficiency, quality, timeliness and safety) that will impacted by main factors that were listed in first section. Finally, the last section of the questionnaire contained implementation barriers of supply chain management and most important processes frequencies in the supply chain management.

Fact1	Lead-time of manufacturing	Fact13	Transportation flexibility
Fact2	On-time delivery	Fact14	Service level cost
Fact3	Product quality and service	Fact15	Inventory level
Fact4	Customer satisfaction in fulfillment his order	Fact16	Inventory handling and facility
Fact5	Productivity to fill the order	Fact17	Packaging for material handling efficiency
Fact6	Product improvement (variety)	Fact18	Uncertainty of market and customer demand
Fact7	Order accuracy between supply chains	Fact19	Political stability
Fact8	Information accuracy between supply chains	Fact20	Empowering the decision
Fact9	Developing supplier relationship	Fact21	Employee training program
Fact10	Affecting of the coordination on supply chain	Fact22	Competitive change over time
Fact11	Improve the technology used	Fact23	Machine productivity cost
Fact12	Plant and warehouse location from marketplace and customer		

Table 1: Most important factors

4. RESULTS AND DISCUSSION

Data analyses were conducted using the statistical package for social sciences (SPSS). It involved mainly the ranking of variables based on mean values and frequency distribution. Table 1 shows the main key factors considered as significant factors affecting the supply chain drivers and how they are reflected on the performance indicators. In this survey, most of the respondents agreed that factor 2 (on time delivery to the customer) with score 6.6 is the most important performance factor relative to supply chain processes, followed by factor 3 (product quality and service) with score 6.21, factor 4 (customer satisfaction in fulfilment his order) with a score of 6.17, factor 1 (manufacturing lead-time) - 6.1, and factor 15 (inventory level) - 5.98. Meanwhile, the five least important factors were identified as follows; factor 19 (political stability) - 4.71, followed by factor 12 (plant and warehouse location from market place) - 5.1, factor 18 (uncertainty of market and customer demand) - 5.17, factor 14 (service level cost) - 5.18, and factor 22 (competitive change overtime) - 5.2. Although these factors were the least, but are ranked with high scores, which implies that they cannot be ignored, and can be used for further studies.

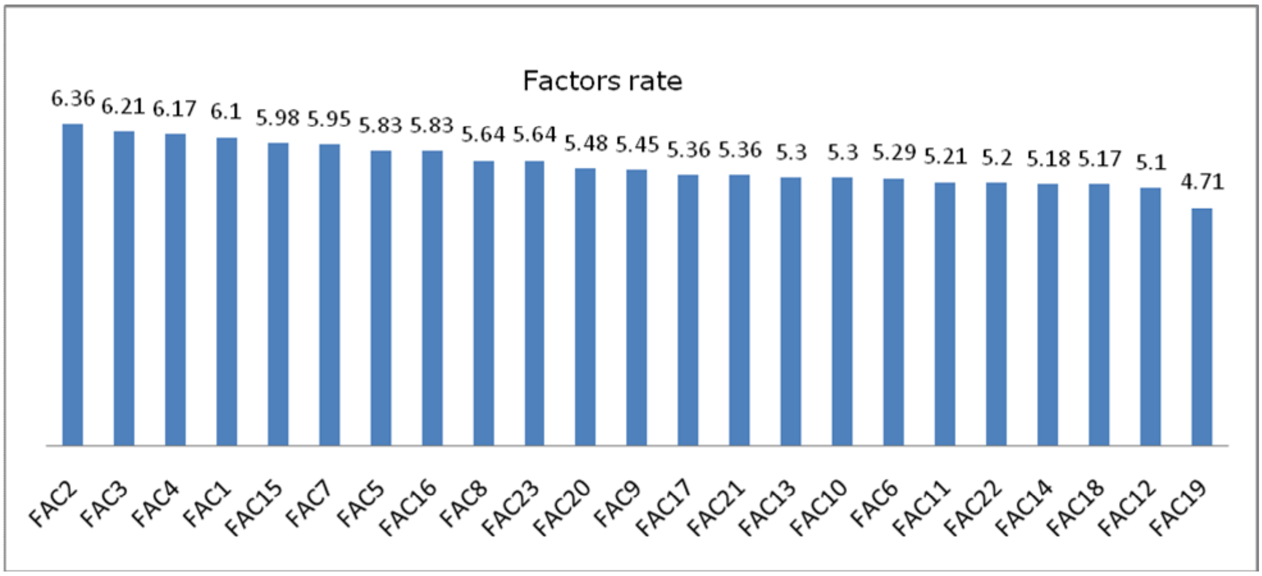

Figure 2: Critical factors for SCM

In addition, the study was able to identify the most important factors that influence the performance indicators (effectiveness, efficiency, productivity, quality, timeliness, and safety). Respondents (44.7%) have ranked factors 2,7,9,10, and 21 as significant elements to improve the effectiveness indicator, and 72.3%, 68.1%, and 66% agreed that these factors (11,8,10 respectively) will affect the efficiency indicator. Also, majority of the respondents (83%) have decided that, product quality and service (fact3) is critical to enhancing the quality indicator followed by factors (17,4) with respondents rate 78.7%, 70.2% respectively. The respondents have agreed that, the timeliness indicator has affected by factors 12,1,2 with rate 76.6%,74.7%, and 66%. The last indicator (safety) has opted to be influenced by factors 12,13 (27.7), and factor 23 (23.4). Besides that, the study figured out the biggest barriers to the implementation of a successful supply chain management. From the barriers that have listed from previous studies, the respondents identified the top management decision (74.5%) as a critical barrier to ensure the success of supply chain management implementation, followed by systems and technology which represents (57.4%), operational impacts and systems integration (55.3%), lack of understanding about new techniques (51.1%), and culture and attitudes of employees (51.1%). On the other hand, the least three important barriers were political stability, low profit margin, and lack of trust with have 8.5%, 14.9 and 14.9 respectively.

5. CONCLUSION

The challenging economic on conditions have placed immense pressure on continued growth and survivability of SCMs. The key challenges faced are contraction in demand and high materials prices, the current global economic and financial crisis as well. For that, the study has presented factors that affect the supply chain processes and performance measurement in SMEs which can give some idea about factors affecting the performance of SMEs in Malaysia. Furthermore, the barriers that challenge the implementation of supply chain management were presented. The outcomes of study figured out that, the importance of satisfaction of the customer should be the main target of the companies, either by delivering of the products on time or produce the desired specification of customer needs. On the other hand, to be successful, supply chain management the top management should make right decision in right time and right place. The application of modern technology and understanding of the techniques used are other issues that affect the implementation of supply chain management. However, the performance of supply chain management practices still not adopted totally in SMEs in Malaysia which make it face challenges to reach a global market level.

REFERENCE

1- Chan F. and Qi. H.J. (2003), *Feasibility of performance measurement system for supply chain: a process-based approach and measures*, Integrated Manufacturing Systems 14/3 (2003) 179-190.

2- Alaa G., James S. Noble, and Crowe T. J. (1997), *An integrated dynamic performance measurement system for improving manufacturing competitiveness*. Int J. Production Economics 48 (1997) 207-225.

3- Koh L. and A. Gunasekaran (2007), *Measuring performance within the supply chain of a large scale project*. Supply Chain Management: An International Journal 12/1 (2007) 52–59.

4- Ross A. D., and Droge C. (2004), *An analysis of operations efficiency in large-scale distribution systems*. Journal of Operations Management 21 (2004) 673–688.

5- Olugu E. U. and Wong K. Y. (2009), *Supply Chain Performance Evaluation: Trends and Challenges*. American J. of Engineering and Applied Sciences 2 (1): 202-211, 2009.

6- Kim S. W. (2006), *Effects of supply chain management practices, integration and competition capability on performance*. Supply Chain Management: An International Journal 11/3 (2006) 241–248.

7- McCormack K., Ladeira M. B., and Paulo M. (2008), *Supply chain maturity and performance in Brazil*. Supply Chain Management: An International Journal 13/4 (2008) 272–282.

8- Cai J., Liu X., Xiao Z., and Liu J. (2009), *Improving supply chain performance management: A systematic approach to analyzing iterative KPI accomplishment*. Decision Support Systems 46 (2009) 512–521.

9- Coşkun A. and Bayyurt N. (2008), *Measurement Frequency of Performance Indicators and Satisfaction on Corporate Performance: A Survey on Manufacturing Companies*. Finance and Administrative Sciences ISSN 1450-2275 Issue 13 (2008).

10- Lai K., Ngai E., and Cheng T. (2002), *Measures for evaluating supply chain performance in transport logistics*. Transportation Research Part E 38 (2002) 439–456.

11- Gilmour P. (1999), A strategic audit framework to improve supply chain *performance*. Journal of business & industrial marketing, VOL. 14 NO. 5/6 1999, pp. 355-363.

12- Green K. W., Whitten D., and Inman R. A. (2008*), The impact of logistics performance on organizational performance in a supply chain context*. Supply Chain Management: An International Journal 13/4 (2008) 317–327.

13- Gunasekaran, Patel C., and McGaughey R. E. (2004), *A framework for supply chain performance measurement*, Int. J. Production Economics 87 (2004) 333–347

14- Thakkar J., Kanda Arun, and Deeshmukh S.G. (2009), *An Supply chain performance measurement framework for small and medium scale enterprises*, Benchmarking: International Journal Vol. 16 No. 5, (2009) pp. 702-723

15- James O'Kane (2004), *Simulating production performance: cross case analysis and policy implications,* Volume 104 · Number 4 · 2004 · pp. 309-321.

16- Gunasekaran A. and Ngai E.W. (2005), *Build-to-order supply chain management: a literature review and framework for development,* Journal of Operations Management 23 (2005) 423–451.

17- Ali Salman and Nelson Ndubisi (2006), *An Evaluation of SME development in Malaysia*, International Review of Business Research Papers Vol.2. No.1 August 2006 pp.1-14.

18- Baba Deros, Yusof S. M. and Salleh A. Md *(2006*), *A Survey on Critical Factors and Problems in Implementing Benchmarking Towards achieving business competitiveness in SMEs*, *Jurnal Kejuruteraan 18 (2006): 29-37.*

SECTION 4 – RISK AND VISIBILITY

RISK PROPAGATION MODEL FOR A DEFENCE FOOD SUPPLY CHAIN

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INTRODUCTION
Securing the defence food supply chain is critical to any defence force since it is the "first line of defence" for a nation, and any disruption in this food supply chain can hamper the ability of an army to function effectively in times of war. History is replete with examples of battles lost because of how the winning side disrupted the food distribution logistics of the losing side. The popular adage that an "an army walks on its stomach" is true even today as a soldier's morale and combat capability depend on the fulfillment of his nutritional requirements.

However, ensuring the continuity and security of the food supply chain has become more challenging and complex with the globalization of food supply chains, greater offshore procurement, and the outsourcing of food production and distribution. Defence forces are always striving to eke out cost savings albeit without compromising on the response and efficiency of the supply line. Therein lies the challenges: dual or multiple sourcing of food zones or supplies creates duplicity in the system but it also enhances operational flexibility by ensuring a steady and alternative stream of food into the stomachs of the soldiers. The attendant concerns in this regard are the risk of contamination of the food supply, lower food quality, exchange rate fluctuations, and uncertainty in the lead times. Therefore to create resilience in the food supply chain, it is imperative to better understand and model the risk involved in the procurement and distribution of food as it moves within the 'farm to fork' supply chain. In this paper, we develop a stochastic risk propagation model to understand the different risk factors that can affect the military or defence food supply chain and how risk propagation through a 2-tier food supply chain can be adequately captured and managed.

LITERATURE REVIEW
Studies on risk management and supply chain vulnerability abound and is a fashionable area of management research (Peck, 2006). Unforeseen natural disasters such as tsunamis, volcanic ash clouds in addition to the man-made events such as wars and regional unrest which cause disruptions in supply chains have provided impetus to the research process. Various interpretations of risk and risk management in supply chains are found in the literature. Both qualitative and quantitative approaches to risk in supply chains have been studied. Our paper seeks to study the risk propagation due to supply uncertainty, demand uncertainty, exchange rate fluctuations and disruptions.

Specifically, Zsidisin (2002) defines supply risk as the potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market in which its outcomes result in the inability of the buying firm to meet demand or cause threats to customer life and safety. Steele and Court (1996), and Zsidisin et al. (2000) studied the assessment of supply risk while Smeltzer and Siferd (1998) illustrated proactive supply management practices involving risk management. Sanders and Manfredo (2002) have proposed estimates of the downside risk on commodities by using a Value-at-Risk approach. Further, Zsidisin (2003) studied the supply characteristics that affect managerial perceptions of supply risk and created a classification of supply risk sources. A review of research on the sources of potential supply risk is also provided by Zsidisin (2003).

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The literature on demand risk in supply chain networks indicates that the increase in the level of market disturbance results in a reduction in the predictability of demand. Indeed, many factors lead to this increase in demand volatility. For example, shorter life cycles due to the fast development of technology leads to a higher risk of obsolescence. Higher levels of competitive activity, such as promotions and sales incentives, increase the demand disturbances in many consumer markets. Global supply chain network management under demand uncertainty has been studied by Cohen and Huchzermeier (1999a, 1999b) using a stochastic programming approach. Supply chain network equilibrium models using variational inequality formulation in the case of random demands, without and with e-commerce in Dong et al. (2003, 2004) and under multi-criteria decision-making in Dong et al. (2002, 2003), were developed. Research incorporating both supply and demand risks is extant in the literature (Smeltzer and Siferd, 1998; Agrawal and Seshadri, 2000; Johnson, 2001; Zsidisin, 2003; Nagurney et al. 2003). In particular, Johnson (2001) investigated the supply chain risk management by studying the toy industry. Further, the supply-demand coordination risk, focusing on the B2B area, has been examined by Kleindorfer and Wassenhove (2003).

In their study of exchange rate related risk, Huchzermeier and Cohen (1996) established a framework for risk management in global supply chain networks with a focus on centralized decision-making and optimization. They employed stochastic dynamic programming to valuate global manufacturing strategy options under an exchange rate risk environment. Later, Cohen and Huchzermeier (1999b) conducted a survey on global supply chain management and provided a stochastic model for supply chain network management under an exchange/price rate risk and demand uncertainty. However, other risk dimensions, such as geopolitical risk, varying country tax rates, and uncertain import tariffs, were left untreated.

Many factors contribute to disruption risks (including natural disasters) for example, the earthquake in Taiwan on September 21, 1999 and the SARS virus outbreak in 2003, and risks arising from purposeful organizations or individuals, such as the September 11, 2001 terrorist attack, and geopolitical risks. Pauchant and Mitroff (1992) provided an overview of research on emergency response, crisis management, and the induced problem of business continuity planning. Kleindorfer and Wassenhove (2003) analyzed disruption risk management in global supply chains. On supply chain security, Lee and Wolfe (2003) discussed some strategic approaches to improving security without jeopardizing supply chain effectiveness. In general, managing disruption risk in global supply chain networks includes the following procedures: identifying the sources of risk, determining the means by which such risks can take place, estimating the potential consequences, and providing the approaches to mitigating and handling these consequences. We will adopt some of these procedures in our paper.

However, studies on the military supply chain are few. Chapell and Peck (2006) applied the six-sigma framework and used the DMAIC (Define, Measure, Analyse, Improve, Control) six-sigma methodology to develop risk management scenarios in military supply chains. In this paper, similar to Chapell and Peck (2006), we examine the case of risk propagation of the food supply chain for the Defence Logistics Organization (DLO) of the military. The logistics process for the DLO falls under three categories: (i) Static Logistics - normal peacetime operational supply chains and infrastructure, (ii) Transit or Coupling Bridge Logistics - moving equipment and stores in preparation for operations, and (iii) Deployed Logistics - supporting operational units in theatre.

RISK PROPAGATION MODEL

Specifically, we study a 2-tier military food supply chain for a nation which is import reliant on food. First tier suppliers who supply directly to the army are termed as local suppliers. These local suppliers procure from overseas suppliers located in different parts of the world. The overseas suppliers in the chain are referred to their original countries or regions. Local and overseas suppliers incur multiple risks in the defence food chain. In our methodology, we consider all possible scenarios of the underlying uncertain risks using a discrete event analysis.

For the players in the food supply chain, we assume that there are *m* potential risks involved. The underlying risks can be estimated by discrete scenarios associated with their respective probabilities, which result in different impacts with different probabilities. The underlying risks are assumed to be independent. In this paper, the impact under consideration refers to the delay in days or the dollar value lost due to the occurrence of the risk p_j^i for any risk r_j, j =1, ..., m. We show how to calculate the impact of these multiple risks together with the respective likelihoods by considering the associated finitely many scenarios concerning the *m* different types of risks. The basic risk profile is shown in Table 1.

Probability of Risk 1	Probability of Risk 2	...	Probability of Risk *m*	Impact
p_1^1	p_2^1	...	p_m^1	r_1
p_1^2	p_2^2	...	p_m^2	r_2
p_1^3	p_2^3	...	p_m^3	r_3
. . .	. . .	. . .	. . .	. . .
p_1^l	p_2^l	. . .	p_m^l	r_l

Table 1: Basic risk profile

Here, $p_i^j \geq 0$, $r_j \geq 0,\ i = 1 \ldots, m,\ j = 1, \ldots \ldots, l, \sum_{j=1}^{l} p_i^j = 1$ and r_j, j = 1,...,l are assumed to be non-negative and distinct, which are ordered in the following way: $0 = r_1 < r_2 < \cdots < r_l$. We allow a situation with zero risk impact. For this purpose, we include the case of $r_1 = 0$ in the above setting.

COMBINING RISKS WITHIN EACH NODE IN THE SUPPLY CHAIN

When finding the combined impact of two or more risks, as shown in the example below, the probability of a certain combined impact is the summation of combined probabilities of that impact taking place. For instance, as shown by Tables 2 and 3, for $\overline{r_2}$=30, risk 1 impact has to be 10 and risk 2 impact should be 20 with $(p_1^1 X\, p_2^2)$ or vice versa $(p_1^2 X\, p_2^1)$ giving a total of $p_1^1 X\, p_2^2 + p_1^2 X\, p_2^1$.

Probability of Risk 1	Probability of Risk 2	Delay/Loss/Shortage
$p_1^1 = 0.08$	$p_2^1 = 0.10$	r_1=10
$p_1^2 = 0.30$	$p_2^2 = 0.20$	r_2=20
$p_1^3 = 0.34$	$p_2^3 = 0.40$	r_3=30
$p_1^4 = 0.20$	$p_2^4 = 0.20$	r_4=40
$p_1^5 = 0.08$	$p_2^5 = 0.10$	r_5=50

Table 2: Risk profile of two disruption risks

Probability of Risk	Delay/Loss/Shortage
$\bar{p}_1 = p_1^1 \times p_2^1 = 0.008$	$\bar{r}_1$=20
$\bar{p}_2 = p_1^1 \times p_2^2 + p_1^2 \times p_2^1 = 0.046$	$\bar{r}_2$=30
$\bar{p}_3 = p_1^1 \times p_2^3 + p_1^3 \times p_2^1 + p_1^2 \times p_2^2 = 0.126$	$\bar{r}_3$=40
$\bar{p}_4 = p_1^1 \times p_2^4 + p_1^2 \times p_2^3 + p_1^3 \times p_2^2 + p_1^4 \times p_2^1 = 0.224$	$\bar{r}_4$= 50
$\bar{p}_5 = p_1^1 \times p_2^5 + p_1^2 \times p_2^4 + p_1^3 \times p_2^3 + p_1^4 \times p_2^2 + p_1^5 \times p_2^1 = 0.252$	$\bar{r}_5$=60
$\bar{p}_6 = p_1^2 \times p_2^5 + p_1^3 \times p_2^4 + p_1^4 \times p_2^3 + p_1^5 \times p_2^2 = 0.194$	$\bar{r}_6$=70
$\bar{p}_7 = p_1^3 \times p_2^5 + p_1^4 \times p_2^4 + p_1^5 \times p_2^3 = 0.106$	$\bar{r}_7$= 80
$\bar{p}_8 = p_1^5 \times p_2^4 + p_1^4 \times p_2^5 = 0.036$	$\bar{r}_8$= 90
$\bar{p}_9 = p_1^5 \times p_2^5 = 0.008$	$\bar{r}_9$= 100

Table 3: Risk profile after combining two disruption risks

ADDITIVE AND MULTIPLICATIVE MODELS FOR RISK PROPAGATION

Additive and multiplicative models are basic models for data analysis (Gonzalez and Cox, 2005). For each local supplier $S_j, j = 1, \ldots \ldots I_j$, $(I_j \in \mathrm{N})$, we are interested in the combination of the effects of risk propagation using the additive and multiplicative models. For each supplier S_j, let ϕ_1^j and ϕ_2^j denote the effects of risk propagation associated with the additive model and multiplicative model under consideration, respectively. ϕ_1^j and ϕ_2^j are vectors consisting of 9 levels impact of risks under consideration, with respect to these models, which are denoted by:

$$\phi_1^j = (\phi_{1,1}^j, \phi_{1,2}^j, \ldots \ldots \phi_{1,9}^j)'$$
$$\phi_2^j = (\phi_{2,1}^j, \phi_{2,2}^j, \ldots \ldots \phi_{2,9}^j)'$$

where $\phi_{1,k}^j$ and $\phi_{2,k}^j$, (k=1,….9), are the effects of risk propagation derived by the additive and multiplicative models respectively. In addition, the corresponding probabilities are denoted by $p_1^j = (p_{1,1}^j, \ldots \ldots p_{1,9}^j)'$ and $p_2^j = (p_{2,1}^j, \ldots \ldots p_{2,9}^j)'$. Introducing a control parameter $\rho \in [0,1]$, we find the convex combination of $\phi_1^j$and ϕ_2^j,

$$\hat{r}^j(\rho) := \rho\phi_1^j + (1-\rho)\,\phi_2^j, \text{ j=1, ..., } I_j.$$

Note that $\hat{r}^j(\rho) \in \mathrm{R}^9$, and evidently, it is impractical and unnecessary to calculate all the values of $r^j(\rho)$in implementation. Note that the domain of ρ ranges over [0, 1], then the combined effect of risk falls in the interval $[\underline{r^j}, \overline{r}^j]$ where $\underline{r^j} = \min\{\emptyset_1^j, \emptyset_2^j\}$ and $\overline{r}^j = \max\{\emptyset_1^j, \emptyset_2^j\}$. In this paper, we adopt the commonly used Saaty's 1-9 preference scale in the analysis. This technique was introduced by Saaty (1980, 1982, 1990) in the Analytic Hierarchy Process. This scale allows the expression of the relative importance of performance measures between the above two options. We choose the following values of the parameter ρ: $\rho_1 = 1/9, \rho_2 = 1/8, \rho_3 = 1/7, \rho_4 = 1/6$, $\rho_5 = 1/5, \rho_6 = 1/4, \rho_7 = 1/3, \rho_8 = 1/2, \rho_9 = 1$.

Then, we derive the list of values of risk propagation concerning local supplier j:

$\hat{r}^j(\rho_k), j = 1,2, \ldots \ldots, 7, k = 1,2, \ldots, 9.$

At the same time, the probability associated with $\hat{r}^j(\rho_k)$ equals:

$\hat{p}^j(\rho_k) = \rho_k\, p_1^j + (1-\rho)p_2^j.$

For a fixed $\rho_k, k = 1, 2, \ldots, 9,$ we then have the profile of risk propagation:

$\{\hat{r}^j(\rho_k), \hat{p}^j(\rho_k)\}$, j=1, ...,$I_j$

At the same time, there are different risks at the node of the local supplier j in the supply chain. We then combine the above combined risk (Table 3) with the risk propagation based on the algorithm proposed below, and derive the risk profiles of the local suppliers accordingly.

Risk profile of Single Food Product Associated with Multiple Countries
For a certain food product, suppose there are *m* countries that can supply this food type to the defence caterers (distributors), denoted by $C_1, C_2, \ldots, C_m$.

For the portion of the total food product corresponding to country C_i, the risk profile is shown in Table 4. For i= 1, …, m, $r_i = (r_{i,0}, r_{i,1}, \ldots .. r_{i,q-1}, r_{i,q_i}) \in R$. $q_i + 1$ denotes the set of impact of risk with respect to country C_i, where there are $(q_i + 1)$ levels of impact under consideration. We now investigate the risk profile of the food product associated with the underlying *m* countries using the following algorithm.

Probability	Impact (delays)
$p_{i,0}$	$r_{i,0}$
$p_{i,1}$	$r_{i,1}$
. . .	. . .
$p_{i,q_{i-1}}$	$r_{i,q_{i-1}}$
p_{i,q_i}	r_{i,q_i}

Table 4: Risk profile associated with country $\boldsymbol{C_i}$

Algorithm
Step 1: Calculate *h*:=max{ $r_{1,q1}, \ldots, r_{m,qm}$}. Let I:={1,2,…,*m*}; $I_1 := \{i \in I | r_{i,q_i} = h\}$; and $I_2 := I \backslash I_1$, that is, $I_2 = \{i \in I | r_{i,q_i} < h\}$.

Step 2: For $i \in I_1$, calculate the accumulated probabilities with respect to all possible scenarios of the delay i.e. the delay equals to zero; the delay is less than or equals to 1 day; the delay is less than or equals to 2 days; and so on; the delay is less than or equals to *h* days. Using Table 4,

calculate $\bar{p}_{i,0}=p_{i,0}$; $\bar{p}_{i,1}=\bar{p}_{i,0}+p_{i,1}$; $\bar{p}_{i,2} = \bar{p}_{i,1}+p_{i,2}$; … ; $\bar{p}_{i,q_i} = \bar{p}_{i,q_{i-1}}+p_{i,q_i}$.

The risk profile concerning the accumulated probability with respect to Country $\boldsymbol{C_i}$ $(i \in I_1)$ is designed as follows.

Probability (Accumulated)	Delays (Less than)
$\bar{p}_{i,0}$	$r_{i,0}$
$\bar{p}_{i,0}+\frac{\bar{p}_{i,1}-\bar{p}_{i,0}}{\bar{r}_{i,1}-\bar{r}_{i,0}}$	$r_{i,0}+1$
$\bar{p}_{i,0}+\frac{2\,(\bar{p}_{i,1}-\bar{p}_{i,0})}{\bar{r}_{i,1}-\bar{r}_{i,0}}$	$r_{i,0}+2$
………	………
$\bar{p}_{i,0}+\frac{(r_{i,1}-r_{i,0}-1)(\bar{p}_{i,1}-\bar{p}_{i,0})}{\bar{r}_{i,1}-\bar{r}_{i,0}}$	$r_{i,0}+(r_{i,1}-r_{i,0}-1)$
$\bar{p}_{i,1}$	$r_{i,1}$
$\bar{p}_{i,1}+\frac{\bar{p}_{i,2}-\bar{p}_{i,1}}{\bar{r}_{i,2}-\bar{r}_{i,1}}$	$r_{i,1}+1$
$\bar{p}_{i,1}+\frac{2(\bar{p}_{i,2}-\bar{p}_{i,1})}{\bar{r}_{i,2}-\bar{r}_{i,1}}$	$r_{i,1}+2$
……..	……
$\bar{p}_{i,1}+\frac{(r_{i,2}-r_{i,1}-1)(\bar{p}_{i,2}-\bar{p}_{i,1})}{\bar{r}_{i,2}-\bar{r}_{i,1}}$	$r_{i,1}+(r_{i,2}-r_{i,1}-1)$

$\bar{p}_{i,2}$	$r_{i,2}$
....	....
$\bar{p}_{i,3}$	$r_{i,3}$
....	....
1.0	$h = r_{i,q_i}$

Step 3: For $i \in I_2$, the risk profile concerning the accumulated probability is constructed in the following way.

Probability (Accumulated)	Delays (Less than)
$\bar{p}_{i,0}$	$r_{i,0}$
$\bar{p}_{i,0} + \frac{\bar{p}_{i,1} - \bar{p}_{i,0}}{r_{i,1} - r_{i,0}}$	$r_{i,0} + 1$
$\bar{p}_{i,0} + \frac{2\,(\bar{p}_{i,1} - \bar{p}_{i,0})}{r_{i,1} - r_{i,0}}$	$r_{i,0} + 2$
...	...
$\bar{p}_{i,0} + \frac{(r_{i,1} - r_{i,0} - 1)(\bar{p}_{i,1} - \bar{p}_{i,0})}{r_{i,1} - r_{i,0}}$	$r_{i,0} + (r_{i,1} - r_{i,0} - 1)$
$\bar{p}_{i,1}$	$r_{i,1}$
$\bar{p}_{i,1} + \frac{\bar{p}_{i,2} - \bar{p}_{i,1}}{r_{i,2} - r_{i,1}}$	$r_{i,1} + 1$
$\bar{p}_{i,1} + \frac{2(\bar{p}_{i,2} - \bar{p}_{i,1})}{r_{i,2} - r_{i,1}}$	$r_{i,1} + 2$
...	...
$\bar{p}_{i,1} + \frac{(r_{i,2} - r_{i,1} - 1)(\bar{p}_{i,2} - \bar{p}_{i,1})}{r_{i,2} - r_{i,1}}$	$r_{i,1} + (r_{i,2} - r_{i,1} - 1)$
$\bar{p}_{i,2}$	$r_{i,2}$
...	...
$\bar{p}_{i,3}$	$r_{i,3}$
...	...
1.0	r_{i,q_i}
1.0	$r_{i,q_i} + 1$
...	...
1.0	$r_{i,q_i} + (h - r_{i,q_i} - 1)$
1.0	h

Step 4: Rewrite the risk profile of the country C_i with the accumulated probabilities as:

Probability(Accumulated)	Delays(Less than)
$\bar{p}_{i,0}$	0
$\bar{p}_{i,1}$	1
. . .	. . .
$p_{i,h} - 1$	$h - 1$
$p_{i,h}$	h

Step 5: The combined risk profile of the food product for the underlying *m* countries is

Probability(Accumulated)	Delays(Less than)
$\tilde{p}_0 := \sum_{i=1}^{m} \rho_i \, \bar{p}_{i,0}$	0
$\tilde{p}_1 := \sum_{i=1}^{m} \rho_i \, \bar{p}_{i,1}$	1
$\boldsymbol{\tilde{p}_2 - \tilde{p}_1}$	2
. . .	. . .
$\tilde{p}_{h-1} := \sum_{i=1}^{m} \rho_i \, \bar{p}_{i,h-1}$	$h-1$
$\tilde{p}_h := \sum_{i=1}^{m} \rho_i \, \bar{p}_{i,h}$	h

CONCLUSION

Using the example of a 2-tier defence food supply chain, this paper develops a methodology to combine risks which local and overseas suppliers face in the food supply chain. Additive and multiplicative models are used to determine the combined effects of different types of risks which arise due to natural disasters such as floods, famines and man-made disasters such as war, political unrest amongst others. A risk profile for each country is developed, which can be used to understand and mitigate the risk in the defence food supply chain.

REFERENCES

Agrawal V and Seshadri S (2000), "Risk intermediation in supply chains", *IIE Transactions, 32*, 819-831.

Chapell A and Peck H (2006), "Managing risk in the Defence supply chain: Is there a role for six sigma?" *International Journal of Logistics Research & Applications*, 9, 3, 253-267.

Cohen MA & Huchzermeier A (1999a), "Global supply chain network management under price/exchange rate risk and demand uncertainty" in Muffato M and Pawar KS (Eds.): *Logistics in the Information Age*, SGE Ditorali, 219-234.

Cohen MA & Huchzermeier A (1999b), "Global supply chain management: a survey of research and applications," in Tayur S et al. (Eds.): *Quantitative Models for Supply Chain Management*, Kluwer Academic Publishers, 669-702.

Dong J, Zhang D & Nagurney A (2002), "Supply chain networks with multicriteria decision-makers," *Transportation and Traffic Theory in the 21st Century*, Pergamon Press, Amsterdam: Holland.

Dong J, Zhang D & Nagurney A (2003) "Supply chain super networks with random demands," in Lee DH (ed.): *Urban and Regional Transportation Modeling: Essays in honor of David E. Boyce*, Edward Elgar Publishers, Cheltenham: England.

Dong J, Zhang D & Nagurney A (2004), "A supply chain network equilibrium model with random demands," *European Journal of Operations Research*, 156,194-212.

Gonzalez AB & Cox DR (2005), "Additive and multiplicative models for the joint effect of two risk factors," *Biostatistics,* 6, 1-9.

Huchzermeier A & Cohen MA (1996), "Valuing operational flexibility under exchange rate uncertainty", *Operations Research, 44*, 100-113.

Johnson ME (2001), "Learning from toys: lessons in managing supply chain risk from the toy industry," *California Management Review*, 43, 106-124.

Kleindorfer PR & Wassenhove LV (2004), "Managing risk in global supply chains," *The Alliance on Globalization*, Gatigon H and Kimberly J (Eds.), Cambridge University Press.

Lee HL and Wolfe M (2003), "Supply chain security without tears," *Supply Chain Management Review*, Jan/Feb, 12-20.

Nagurney A, Cruz J & Matsypura D (2003), "Dynamics of global supply chain supernetworks", *Mathematical and Computer Modelling, 37*, 963-983.

Pauchant TC & Mitroff I (1992), *Transforming the crisis-prone organization*, Jossey-Bass: San Francisco.

Peck H (2006), "Reconciling supply chain vulnerability with risk and supply chain management", *International Journal of Logistics Research and Applications*, 9, 2, 127-142.

Saaty TL (1980) *The Analytic Hierarchy Process*, McGraw-Hill: New York.

Saaty TL (1982) "How to Structure and Make Choices in Complex Problems", *Human Systems Management, 3-4*, 255-260.

Saaty TL (1990), *Multicriteria Decision Making: The Analytic Hierarchy Process*, RWS Publications: Pittsburgh.

Sanders DR & Manfredo MR (2002), "The role of value-at-risk in purchasing: an application to the foodservice industry," *Journal of Supply Chain Management*, 38, 38-45.

Smeltzer LR & Siferd SP (1998), "Proactive supply management: the management of risk," *International Journal of Purchasing and Materials Management*, 34, 38-45.

Steele PT and Court BH (1996), *Profitable purchasing strategies: A manager's guide for improving organizational competitiveness through the skills of purchasing*, McGraw-Hill: London.

Zsidisin GA (2002) "A grounded definition of supply risk," *Journal of Purchasing and Supply Management*, 9, 217-224.

Zsidisin GA (2003) "Managerial perceptions of supply risk," *Journal of Supply Chain Management*, 39, 14-25.

Zsidisin GA, Panelli A and Upton R (2000), "Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study," *Supply Chain Management: An International Journal*, 5, 187-197.

ASSESSING RISKS, THEIR VISIBILITY AND CONTROL IN MARITIME SUPPLY CHAINS

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INTRODUCTION

Supply chain complexity and disintegration are emerging as major challenges in supply chain risk management. As logistic operations are getting more divided between an increasing number of individual actors, the ability to identify risks decreases and the visibility of the supply chain diminishes. The increasing demands for transportation performance, higher on-time delivery performance and reduced damage-in-transit, however, require high flexibility to adapt to changes. The companies' livelihood depends on their ability to identify and mitigate the risks facing them. In their studies Harland et al. (2003) came to the conclusion that in the supply chains examined, less than 50% of the risk was visible to the focal company.

The ability to identify the risks has decreased, as the control and visibility of the supply chain operations have fallen to the hands of outside service providers. The risks, their visibility and their impact depend on the position of the companies in the supply chain and on the level of analysis companies can carry out. Events affecting one supply chain entity or process may interrupt the operations of other supply chain members. Supply chain disruptions have become a critical issue for many companies. Hence, it is important to investigate supply chains across borders when selecting and implementing supply chain risk management strategies (Manuj & Mentzer 2008).

Global supply chains are stretching over longer distances with increasingly complicated networks and a growing number of actors. These complex chains require highly coordinated flows of goods, services, information and money within and across national boundaries (Mentzer 2001). Although the awareness of supply chain vulnerability and risk management is increasing among practitioners, the concepts are still in their infancy and there is a lack of conceptual frameworks and empirical findings to provide a clear meaning of the phenomenon of global supply chain risk management (Jüttner 2005; Manuj & Mentzer 2008).

In this paper we present preliminary research concepts and findings, concerning the identification and analysis methods of supply chain risks, as well as risk management control approaches between supply chain members. The main aim of this study is to present an analysis of supply chain risk identification and control that the focal supply chain actors can carry out. The study is based on both the literature concerning supply chain risk management and the findings from interviews conducted. The studied companies are a part of a maritime supply chain from the Baltic Sea to inland Finland. Even though there are several studies on supply chain risk management in the current literature, only a few of them address the maritime supply chain perspective. This paper attempts to fill that gap in the literature by assessing supply chain risks holistically in the maritime supply chain.

In order to tap into the supply chain professionals' experience and knowledge, a discovery-oriented approach was applied with semi-structured interviews as the primary method of data collection. The data is verified following the Delphi method by group discussions. The chosen research approach is twofold, as it both investigates the relationships between individual companies and provides a holistic view of the focal supply chain. The case was conducted by interviewing practitioners and hearing their views from different parts of the supply chain. The supply chain process and the structure of the supply chain are mapped and the levels of risk management and co-operation analyzed.

SUPPLY CHAIN RISK MANAGEMENT

In the literature concerning supply chain management, *risk* is defined as purely negative and seen leading to undesired results or consequences (Harland et al. 2003; Manuj & Mentzer 2008). A standard formula for the quantitative definition of supply chain risk is
*Risk = P(Loss) * I(Loss),*
where *risk* is defined as the probability (P) of loss and the significance of its consequences (I).(Mentzer et al. 2001)

Risks in the supply chain can come in many forms: Firstly, they can be operational and considered to be minor by their consequences but occurring regularly. These risks can cause disturbances in the supply chain that are not deemed to be serious. However, when occurring simultaneously or when causing a snowball effect, these risks can have serious repercussions. Secondly and more commonly considered, disruptive risks are described by Tang (2006) as low probability–high consequences (LP–HC) events. These events can unexpectedly disrupt the flow of material in the supply chains at any time.
Jüttner (2005) describes *vulnerability* as an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain. According to Waters (2007), supply chain vulnerability reflects the susceptibility of a supply chain to disruption and is a consequence of the risks to the chain. Furthermore, Jüttner (2005) describes supply chain vulnerability as the propensity of risk sources and risk drivers to outweigh risk mitigating strategies, thus causing adverse supply chain consequences and jeopardizing the supply chain’s ability to effectively serve the end-customer market. How sensitive a supply chain is to these disturbances is measured by its vulnerability. How vulnerable a supply chain is to disturbances depends on its structural agility and resilience, where supply chain (risk) management plays a crucial role.

Increasing risks in the supply chain are a current trend in logistics (Minahan 2005). According to Singhal et al. (2009), supply chain disruptions have become a critical issue for many companies. The categorization of supply chain risks has many variations. Modern literature offers many possibilities for categorizing risks and they should be considered according to the supply chain in question. Blackhurst et al. (2008) argue that the most important step during the process of risk assessment is the selection and definition of categories of risks, which can be weighted, compared and quantified. The state-of-the-art literature offers many ways to categorize risks; some are industry specific and others general.

Jüttner et al. (2003) argue that supply chain risk management consists of four key management aspects: (1) assessing risk sources, (2) defining the supply chain adverse consequences, (3) identifying the risk drivers, and (4) mitigating risks for the supply chain.

In their article Rao and Goldsby (2009) highlight the importance of risk sources and propose that the overall risk is the sum of environmental factors, industry factors, organizational factors, problem specific factors and decision-maker factors. In our investigations, however, it was noticed that the effects of the risks also play an important role when analyzing them and implementing a proper risk management strategy. In the focal supply chain the impacts of risks were discovered to be of three types: time-based, financial-based and quality-based.

One of the key factors in supply chain risk management is the visibility of the risks, which is recognized by many authors (i.e. Caridi et al. 2009; Al-Mudimigha et al. 2004). Most authors agree that visibility in the supply chain provides benefits in operations efficiency (e.g. Smaros et al. 2003), productivity and effective planning (e.g. Petersen et al. 2005).

In the interviews conducted for our study, an organization's visibility seemed to depend on the level and form of their co-operation inside the supply chain. Here the globally operating logistic companies had a fairly good visibility of the risks facing them and the level of analysis was among the highest of the studied organizations. Co-operation was mainly done on the vertical level with service provider companies; however, horizontal co-operation and information exchange with other globally acting companies did not seem to have a role. In the interviews conducted the form of co-operation seemed to shift from the vertical level to the horizontal one when moving from the global to local firms so that in the trucking companies co-operation was mainly on the horizontal level with competitors, which decreased the visibility of the risks in the supply chain. The willingness to co-operate and increase visibility varied between the companies, but the overall intense competition in the trucking sector seemed to promote the willingness to co-operate also on the vertical level (Figure 1).

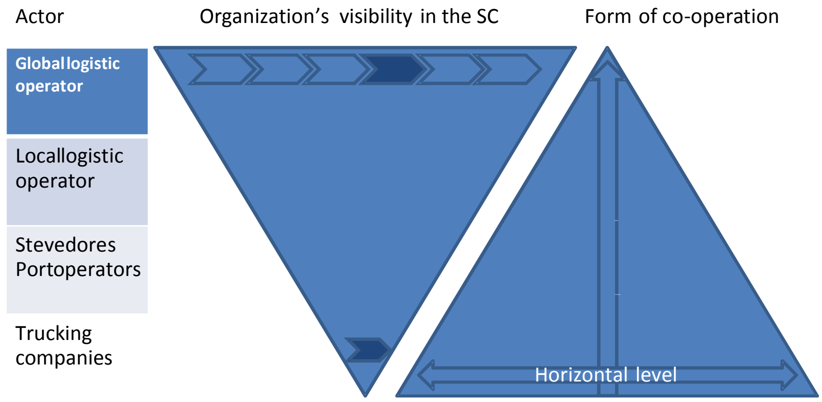

Figure 1. Different actors' visibility and form of co-operation in the focal supply chain

EMPIRICAL STUDY AND METHODS

The study was done as part of a larger study, STOCA, which examines the cargo flows in the Gulf of Finland in emergency situations. As part of this study the interviews were conducted with a cross-section of companies that acted in the supply chain from the Gulf of Finland to the Finnish mainland.

Maritime supply chains have an important role in the global transportation system. The traffic density of many maritime supply chains is high, and the narrow and shallow shipping lanes pose a serious risk to the cargo flows going through them. Even though there are several studies on supply chain risk management in the current literature, only a few of them have addressed the maritime supply chain perspective. In this study, the risks affecting the cargo flows in the Gulf of Finland are investigated and reflected upon from the perspective of inland transportations as well as downstream in the supply chain. Disruptions in the downstream supply chain can also affect the Gulf's maritime transportation in the case of a disaster in or near the ports.

The aim was to understand how risks faced by the supply chain between the Gulf of Finland and inland Finland are seen by the practitioners in the supply chains and how they can be controlled. In order to tap into the supply chain professionals' experience and knowledge, a discovery-oriented approach was applied with semi-structured interviews as the primary method of data collection (Zaltman 1982; Yin 1989). The interviewees were selected from the companies best representing their field and with high significance to the area of operations. All of the interviewed companies were a part of the focal supply chain and acting in different parts of it, representing road, rail and maritime transportations, ports and port operators, an insurance company and international logistics operators. The interviews were conducted with persons from a range of supply chain manager related duties. The position of the interviewees varied by the company, but all had an extensive understanding of their company's operations. The interviews were conducted by researchers of different specialization backgrounds to get as broad a view of the subject as possible and to ensure the reliability of the study and its viability as the basis for further work. In the beginning of each interview, the interviewees were promised anonymity and their permission to use a recorder was solicited. Afterwards the recorded interviews were transcribed and sent to the interviewed parties for possible correction and acceptance.

The participating companies were all actors in the supply chain studied. The scale of conceptual understanding and comprehension of risks varied highly between 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. Some of the trucking companies had their own simple ways to identify and respond to risks i.e. by simple feedback forms filled in by the employees and analyzed by the managers. In larger logistic companies, which 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 was used in this study as well.

IDENTIFIED RISKS

Supply chain risks from the Gulf of Finland to the Finnish mainland were the focus of the interviews, which were conducted with 23 managerial practitioners in the focal supply chain. The risk seen by the practitioners varied between the companies, but some of the same risks were also mentioned in every interview. The identification of the supply chain risk and overall risk management were on a lower level in the smaller companies (e.g. trucking) than in those operating with a wider perspective in the supply chain. Also, the personal differences between managers and their interpretations were significant. The transport supply chain process map presented in Figure 2 was created to identify the risks associated with the maritime supply chain under investigation. The map shows the higher-level steps in the supply chain process and allows us to focus on each supply chain stage in-depth without losing the connections between the supply chain stages.

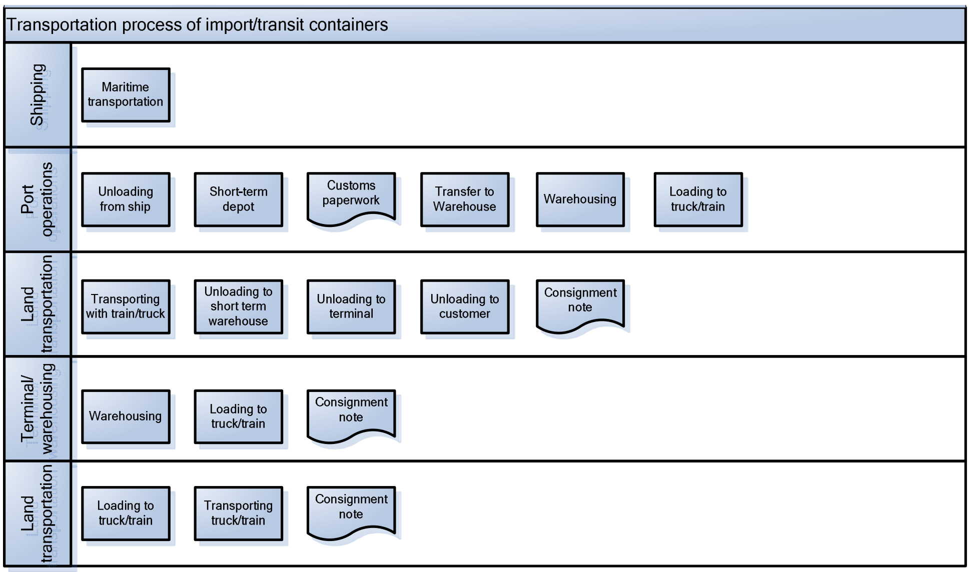

Figure 2. The supply chain processes for risk analysis

The port operators interviewed recognized the financial crisis and human factors (e.g. irresponsibility, poor motivation, alcohol) to be the most severe risks. The port managers also had their own view of risks, and the responses varied according to the persons' position and background. The managers responsible for security did not typically see the market risk to be relevant, whereas, the development or traffic manager saw them higher compared to, for example, terrorism. The 9/11 disaster still affected the business from every interviewee's point of view.

A surprising point found from the interviews was the poor state of preparedness that the companies had for any disruptions, no matter how insignificant they were considered and how little co-operation there was between the organizations operating in the same supply chain. The co-operation and communication between the parties was usually only at a level that was compulsory or necessary to conduct business. A lot of suspicion still remains in the logistics and transportation field which decreases the co-operation and visibility of the supply chain. One of the reasons for this is the intense competition which especially in the times of economic crises seems to take a strong hold of the managers.

One of the main findings was the routes to and from the ports: not only the narrow shipping lanes but also the land routes; in every major port there was either a bottle neck or a critical risk in the road or tracks. These were noticed in the ports but only few of the identified risks had been assessed properly. If the usage of these vital routes was prevented, the capacity of the port would be significantly lower or even disrupted. This would have an instant effect on the cargo flows in the case supply chain. Because of the specialization of the biggest ports in Finland the transferring of cargo that requires special handling equipment would be difficult. Also a stoppage with cargo onboard was considered to be a high risk in certain cases; if the transported good had some applications that would interest third parties or if the neighborhood was bad this was considered a high risk. Therefore, information sharing and co-operation were seen essential for managing this risk.

Among the most significant risks was also the power that the labor union (of stevedores and truck drivers) has with strikes, which came up in every interview. The actions of the trade union had even prevented interfunctional co-operation between the companies of the supply chain, which illustrates the complexity of the relationships and risks and the attitude of the operational environment towards developments in the supply chain.

Slipperiness in wintertime seemed to cause problems in almost every company interviewed – although the company did not necessarily identify it as a risk itself, but another member of the supply chain that had a different perspective on the processes. This seemed to be challenging to control especially in the companies that operated in other's property or if the maintenance was outsourced. When the companies did not have a direct control over the mitigating procedures, the controlling either took time to do by the partner or was even neglected because it did not directly relate to the partner's own processes.

RISK VULNERABILITY, VISIBILITY AND CONTROL

In the constructive part, the research process is divided into three steps: investigation of risks (vulnerabilities), risk visibility and risk control. These steps are demonstrated in the following. The risks in the maritime supply chain were explored in two sequential stages. In the first step, the supply chain risks were identified in the process step levels illustrated in Figure 1. The FMEA (Failure Mode and Effect Analysis) framework was used for investigating the potential failure modes and their causes and effects in the supply chain processes. FMEA allows identifying and analyzing potential failure modes in a system, and identifying actions that could eliminate or reduce the likelihood of potential failure (Chuang 2002). The example breakdown of FMEA is shown in Table 1 where some of the process steps and their illustrative failure modes are analyzed. The focus on each step at a time provides a comprehensive framework for analyzing and comparing a vast set of risks encountered in the supply chain.

Actors	Supply chain process	Potential failure mode	Potential failure effects	Potential cause	Severity (1-10)	Likelihood (1-10)	Detection (10-1)	RPN
Shipping company	Maritime transportation	Water gets inside the transported containers	Product damaged	High waves in the Gulf of Finland, caused by climate change	8	2	5	**80**
Port operator	Unload the shipment	Product dropped while unloading	Product damaged	Poor skills of employees, poor condition of the unloading equipment	4	3	7	**84**
Port operator	Lodging in warehouse	Port employees' and truck drivers' strike	End customer loses its customers	Labor union conflict with employers	7	5	3	**105**
Port operator	Loading the truck	Product slips from the forklift during loading	Product and truck damaged, driver injured	Slipperiness in wintertime	5	6	3	**90**
Trucking company	Transportation to the customer	Organized crime, terrorism	Shipment stolen	Applications of transported goods, Stoppage made cargo onboard	9	1	8	**72**
Trucking company	Unloading at customer	Product dropped from the forklift	Product damaged, increased insurance costs	Poor accuracy and motivation in handling the equipment	2	6	8	**96**

Table 1. FMEA analysis

When utilizing the supply chain FMEA, it can be recognized that supply chain vulnerabilities occur in different parts of the chain. This holistic picture of vulnerabilities is essential when the visibility of recognized supply chain risks is connected to the actors in the supply chain. This connection can be analyzed by using the relationship matrix tool shown in Table 2. In the matrix, the actors' visibility of each risk is mapped on a scale from 0 to 10, where 0 indicates no visibility and 10 very good visibility by the actor. Each relationship measure is calculated with an RPN measure to demonstrate the importance of risk visibility. The horizontal row shows how visible each risk is. For example, the item *Labour union conflict* has rather weak visibility (3%) in the example supply chain system, whereas, *Slipperiness in wintertime* is the most visible risk (27%) in the system.

		Actors in supply chain				
		Shipping company	Port operator	Trucking company		
Risk	**RPN**				**Sensitivity**	**%**
High waves in the Gulf of Finland	**80**	8	5	1	**1120.00**	**20 %**
Poor skills of the employees	**84**	4	6	3	**1092.00**	**19 %**
Labor union conflict with employers	**15**	1	5	5	**165.00**	**3 %**
Slipperiness in wintertime	**90**	2	7	8	**1530.00**	**27 %**
Stoppage made cargo onboard	**105**	1	6	2	**945.00**	**17 %**
Poor accuracy and motivation in handling of equipment	**96**	1	2	5	**768.00**	**14 %**
Total importance		**1372**	**2431**	**1817**	**5620**	
Relative value %		24.4 %	43.3 %	32.3 %		

Table 2. Risk visibility analysis

In similar vein, risk control can be connected to each supply chain risk. In this stage, the actors' ability to control risks is evaluated on a scale from 0 to 10, where 0 indicates no control and 10 very good control by the actor. Shown in Table 3, the risk control matrix illustrates that the actors in the case supply chain system have the lowest overall control over *Labour union conflict with employees* (5%) and highest control over the risk of *Poor skills of the employees* (23%).

		Actors in supply chain				
		Shipping company	Port operator	Trucking company		
Risk	**RPN**				**Sensitivity**	**%**
High waves in the Gulf of Finland	**80**	6	1	0	**560.00**	**13 %**
Poor skills of the employees	**84**	3	9	0	**1008.00**	**23 %**
Labor union conflict with employers	**15**	0	6	8	**210.00**	**5 %**
Slipperiness in wintertime	**90**	0	9	1	**900.00**	**21 %**
Stoppage made cargo onboard	**105**	0	1	7	**840.00**	**19 %**
Poor accuracy and motivation in handling of equipment	**96**	0	0	9	**864.00**	**20 %**
Total importance		**732**	**1841**	**1809**	**4382**	
Relative value %		16.7 %	42.0 %	41.3 %		

Table 3. Risk control analysis

As illustrated in the tables above, visibility and control aspects do not necessarily meet. From the method introduced these risks can be identified, and according to their risk priority number they can be managed properly. In the presented tables, for example, slipperiness in wintertime and stoppage made cargo onboard were identified as such. Those require increased collaboration from the supply chain actors in order to increase their visibility and implement effective controlling measures to these risks. An illustrated comparison between the visibility and control aspects can offer valuable insights for improving supply chain resilience. The visibility and control analyses also reveal the gaps in information and co-operation between the supply chain members.

CONCLUSIONS

Supply chains are increasingly complex and vulnerable to various risks. A complete understanding of the consequences of the risks is impossible to achieve. In their studies, Harland et al. (2003) came to the conclusion that in the supply chains examined, less than 50% of the risk was visible to the focal company. This study concurs with that but adds that there are significant differences between the companies and persons behind them. As a main finding, this study shows how co-operation is important in the supply chain context as the visibility of the risks and their control mechanisms do not necessarily reside in the same company. In such cases applying a holistic risk management perspective would bring benefits, as the visibility of the supply chain could enable effective management on the process level as well.

The main objective of this study was to identify and assess the risks affecting the Gulf of Finland cargo flows as well as to analyze the visibility and control aspects of the focal chain. The studying of maritime supply chains is yet in its infancy; therefore, the study was mostly based on interview results and their analysis. The interviews were semi-structured and exploratory by nature and conducted with organizations acting as part of a supply chain originating from the Gulf of Finland and ending up in the Finnish mainland. Given the background of the interviewees, the conceptual clarity of the risk, risk sources and risk drivers were not always clear which was taken into consideration; the interviewees rather responded with tales of cause and effect. In this respect the findings concur with Peck et al. (2005) and Zsidisin (2003) who noticed that practitioners perceived risk as a multi-dimensional construct. The low-hierarchy trucking companies seemed to have only some idea about the functions they were conducting in the supply chain and how a disruption would affect the chain. Typically, their perspectives were narrow, single-functioned and logistics based.

The risks were seen differently in each company even if there were many same concerns. The level of risk management varied highly between the organizations interviewed in the focal supply chain. The risks to the supply chain were not recognized 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 risks varied highly between the interviewees. The risks identified as the most severe ones, slipperiness in wintertime and strikes, are not only affecting the whole chain, but also existing in most parts of the chain; they would, therefore, benefit the most from co-operation. The most vital parts of the supply chains from the Gulf of Finland in the eyes of the interviewed companies were the port infrastructure and the land routes near the ports. Typically, ports are specialized 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 the electricity and IT outage.

Many of the risks facing the supply chains could be mitigated by co-operation and proper supply chain risk management. Some of the companies had attempts to introduce co-operation but the lack of trust seemed to prevent deeper involvement which usually stayed on the necessary level and prevented deeper co-operation and information sharing. Practitioners will benefit from the study conducted as its helps better to understand the value of supply chain risks and their assessment. In order to understand all the benefits from increased co-operation further studies should be conducted.

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

Caridi M, Crippa L, Perego A, Sianesi A and Tumino A, (2009) "Do virtuality and complexity affect supply chain visibility?", International Journal of Production Economics, In press, corrected proof.

Chuang P T (2002) “Combining Service Blueprint and FMEA for Service Design”, The Service Industries Journal Vol. 27, No.2, pp. 91–104.

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.

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”, The 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.

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.

Waters D (2007) “Supply chain risk management: Vulnerability and resilience in logistics”, Kogan Page Limited. ISBN-13: 978-0-7494-4854-7

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.

METHODOLOGICAL REVIEW OF SUPPLY CHAIN RISK MANAGEMENT RESEARCH

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ABSTRACT
Supply chain risk management (SCRM) is an emerging research area in the 21st century. The purpose of this paper is to investigate the status of SCRM research in the last 10 years from the standpoint of methodologies applied, and to discuss implications for future research. The empirical evidence used is based on a sample of scientific papers mainly found in the ABI/INFORM database which are published from 1999 to 2008. The status of research is assessed by examining research methodology, level of research issue, research design applied, contribution, main theory applied, and country of the first author. SCRM research is at the early phase of evolution. To take the next step in the evolution process, the discipline of SCRM needs more theoretical contribution based on empirical data collection and rigorous research process, rather than practical conceptual framework only based on desk work. Survey scores the lowest among all the research methods used, hence there are hopes in the future there will be more research about theory testing by survey. It is expected that the findings will facilitate future research by adding to the understanding of the characteristics and applicability of methodological choices.

INTRODUCTION
All the efforts to improve supply chain management can be sorted into twofold: directly improving supply chain management to achieve planned objectives, and on the other hand controlling risks that the supply chain may encounter to assure the planed objectives being achieved. Since 2000 emerging supply chain risk management (SCRM) has become a research area of its own (Paulsson, 2003) and is of growing importance, as the vulnerability of supply chains increases (Norman and Jansson, 2004). As an infant research field, SCRM is far more from being mature. The paradigmatic state of it has not been reached and will not be reached within the near future. As a growing discipline it is methodologically fragmented, and researchers face uncertainty on what approaches will serve well in each research situation. Nevertheless mature disciplines have reached a paradigmatic state, in which the research process has clearly articulated understandable rules of what is good practice and what is not (Vafidis, 2007). The motivation for this methodological review comes from the need to develop a better understanding of the approaches applied in SCRM research and the process to maturing. The primary purpose of this paper is to inspect the status of SCRM research in the last 10 years (from 1999 to 2008) in terms of methodologies applied, and to discuss implications for future research.

LITERATURE REVIEW
Literature review is a form of logical induction helping researchers to develop research questions and ideas for various ways by providing an historical perspective of respective research area and an in-depth account of independent research endeavours (Vafidis, 2007; Mentzer and Kahn, 1995). The literature review may be further divided into integrative, methodological and theoretical. The integrative literature review indicates potential research areas, the methodological literature review examines various approaches for undertaking researches, and the theoretical review develops testable hypotheses (Mentzer and Kahn, 1995). Paulsson (2003), Tang (2006), Khan and Burnes (2007) have separately provided integrative review of SCRM for outlining an agenda for future research work. However no methodological literature review of SCRM has been found. Related methodological reviews of logistics and supply chain management

research are listed and shown as follows. The research of logistics and supply chain management is more mature than that of SCRM and would have the similar discipline evolution route. The tendency of future SCRM research would follow the steps or route of logistics and supply chain management research to some extent.

Dunn et al. (1994) applies Meredith model (Meredith et al., 1989) to analyze the research methodologies applied in logistics. Logistics research papers from five journals for the year 1986-1990 are classified. The majority of logistics research tends to fall into three areas: the interpretive/perceptive (27%), artificial/axiomatic (24%), and logical-positivist/perceptive (23%). The review of the articles categorized as perceptive/interpretive and logical positivist (e.g. survey and interview research) reveals that the majority of this type of research did not incorporate a rigorous methodological approach. Dunn et al. (1994) call for a more scientific approach to empirical research in business logistics, especially when latent variables are constituted in the theory.

The earlier and popularly being cited review on research methodologies for logistics and supply chain management is the paper of Mentzer and Kahn (1995). It provides a descriptive statistics and analysis of all the papers published in the *Journal of Business Logistics (JBL*) from 1978 to 1993 by type of research performed, type of methodology used, and type of data analysis. It is shown from the analysis that at the early years of 1990s the logistics discipline was still maturing and it was the time for the discipline to take the next step in the maturation process. The situation of logistics research at that time is very similar to SCRM research today. A maturing scientific discipline mandates a shift toward greater hypothesis testing, more rigorous data analysis, and standard discussion of validity and reliability.

Following the step of Mentzer and Kahn (1995), Sachan and Datta (2005) examine the state of logistics and SCM research from 1999 to 2003 from the standpoint of methodologies. The state of research is assessed by examining the research design, number of hypothesis testing, research methods, data analysis techniques, data sources, level of analysis and country of authors. The review results are compared with Dunn et al. (1994), Mentzer and Kahn (1995) to look for trends. Major findings show that there is an increase in the direct observation methods like case studies. In general, the research is more interpretative in nature. The survey method still holds the highest position. More advanced techniques are being used for data analysis in empirical studies and there had been an increase in hypothesis testing. The current trend in survey research is moving from exploratory to model building and testing. The gaps identified in the review are: the lack of inter disciplinary studies; lacking of innovative application of secondary data, scarce research at inter organisation level and the current state of research has failed to integrate all the firms in the value chain and treat them as a single entity. Owing to positivist methods dominance the research in the discipline is not able to look the system holistically, and more research is focusing at the function or at the firm level. Emphasising on the flow thinking, research work should focus on inter-organisational level and with the researcher treating supply chain as one system. The time has come to expand limited worn-out paradigms whilst considering new research methods from paradigms used in sister fields.

The methodological review provided describes the state and evolution of logistics and supply chain management research from the standpoint of existing methodologies. For the purpose of comparison, this work will follow the pattern of early published reviews by Meredith et al. (1994), Mentzer and Kahn (1995) and Sachan and Datta. (2005).

METHODOLOGY

There are several frameworks found for categorising research methodologies which have been applied to methodological reviews and analyses. The Hussey and Hussey (1997) classification was used by Mangan et al. (2004); the Arbnor and Bjerke (1997) model was adopted by Gammelgaard (2004) and Vafidis (2007); and the Meredith model (Meredith et al., 1989) was applied by Dunn et al. (1994) and Sachan and Datta(2005).

The framework for research methods developed by Meredith et al. (1989), the Meredith model, has two dimensions that enable categorization of research methodologies: the rational versus existential structure of the research process and the natural versus artificial basis for the information used in research. As shown in table 1, the framework explicitly covers all research methodologies commonly used in supply chain management and logistics research. It is more comprehensive and detailed than other similar frameworks. The Meredith model is also adopted in this paper and the review findings will be compared with the earlier published similar research reviews by Dunn et al. (1994), Mentzer and Kahn (1995), Sachan and Datta. (2005).

Kind of information used

NATURAL ↔ ARTIFICIAL

RATIONAL ↕ EXISTENTIAL

Nature of truth

	Direct Observation of Object Reality	People's Perception of Object Reality	Artificial Reconstruction of Object Reality
Axiomatic			Reason/Logic/ theorems, Normative Modelling and Descriptive Modelling
Logical Positivist/Empiricist	Field Experiments and Field Studies	Structured Interviewing and Survey Research	Prototyping, Simulation, Laboratory Experiments
Interpretive	Action Research and Case studies	Historical Analysis, Expert Panels, Delphi and Intensive Interviewing	Conceptual Modelling and Hermeneutics
Critical Theory		Introspective Reflection	

Source: Meredith et al. (1989) and Sachan and Datta. (2005).

Table 1. A framework for research methods

Except for categorizing research methodologies, Vafidis (2007) provided a synthesis typology as an attempt to provide a more comprehensive view of the methodological approaches in logistics. The analysis dimensions consist of level of research problem, level of empirical evidence, named qualitative method, named quantitative method, openness of framework, contribution to theory testing, contribution to theory building, pragmatism, main theory applied, research approach order.

The literature about SCRM consists of scientific papers, conference articles, dissertations and a few reports. The prime source for presentation of new knowledge is scientific journals (Paulsson, 2003), so only papers published in English scientific journals are considered in this research. All the full text scientific papers in the database of ABI/INFORM with "risk" and "supply" in their titles from 1999 to 2008 were downloaded, read or browsed, and analysed. Based on the clues (only abstracts) from ABI/INFORM, full text papers also have been found in Science Direct and Business Source Premier (BSP) databases. Except "risk", similar searches also used uncertainty, vulnerability, security, or reliability as search keywords. Owing to the fact that there is a large quantity of papers published in the area, we were unable to review all extant papers. We delimited ourselves to the scientific papers which focus on risk management of supply chain and have "risk" in their titles. The sample can express the status and trend of SCRM research.

FINDINGS

This section contains the summary of four approaches used to review the papers according to the points raised in table 1: a) Research Methodologies, b) Research Design Applied, c) Main Contribution and d) Main Theories and Tools Applied.

a) Research Methodologies.

Research methodologies applied within reviewed papers are categorized by Meredith model (Meredith et al. 1989, shown in table 1) and the statistical results are presented in table 2 compared with the findings by Sachan and Datta (2005), Mentzer and Kahn (1995), and Dunn et al. (1994). Table 2 shows that major methodologies chosen are conceptual model and math model. 34.6% of all the papers fall in the "interpretive/artificial" paradigm, including conceptual model and literature review. This is because SCRM is a new emerging research area with researchers starting to set up the basic concepts for SCRM by combining risk management and supply chain management, to propose practical frameworks of SCRM for practitioners and to create a research agenda for researchers. The percentage of papers in conceptual modelling paradigm will sharply decrease in the next 10 years. Following the conceptual model, 30.9% of the papers fall in the "Axiomatic/artificial" paradigm, these include reason/logic/theorems, normative modelling and descriptive modelling, all called math model in this research. Traditionally supply chain management is the field for specialists of operations research and management science to show their talents. Researchers have increasing interest to use mathematical approaches to establish decision oriented normative models or descriptive models. It is expected the tendency of applying mathematical models will continue in future works.

	Direct Observation of Object Reality	**People's Perception of Object Reality**	**Artificial Reconstruction of Object Reality**
Axiomatic			Sachan & Datta (2005) 10% Menter & Kahn (1995) 4% Dunn et al.(1994) 24%
Logical Positivist/Empiricist		Sachan & Datta (2005) 35% Menter & Kahn (1995) 54% Dunn et al.(1994) 23%	Sachan & Datta (2005) 5% Menter & Kahn (1995) 15% Dunn et al. (1994) 3%
Interpretive	Sachan & Datta (2005) 16% Menter & Kahn (1995) 3% Dunn et al. (1994) 7%	Sachan & Datta (2005) 7% Menter & Kahn (1995) 14% Dunn et al. (1994) 27%	Sachan & Datta (2005) 6% Menter & Kahn (1995) 10% Dunn et al.(1994) 9%

Source: Based on Meredith et al. (1989).

Table 2. Types of methodologies applied and comparison

The development of a new discipline like SCRM is based on the usage of concepts, definitions, theories, rules and principles from other disciplines (Sachan and Datta, 2005). SCRM is the intersection of supply chain management and risk management theory. Supply chain is an authentic complex system due to its characteristics of multi-entity, multi-link, cross-regional and compound structure which can be easily affected by unfavourable factors both from the outside environment and from the entities in the chain. Hence, it is necessary to borrow theories and tools from other disciplines, or to bring new theories and methods. But at present, typical theories and methods from other disciplines are applied in very few papers. Among the potential approaches to SCRM, holistic approach is hopefully the effective way to theory generation and management practice. Hence, the findings will facilitate future research by adding to the understanding of the characteristics and applicability of methodological choices.

Strictly speaking, our findings cannot simply compare with the findings by Sachan and Datta (2005), Mentzer and Kahn (1995), and Dunn et al. (1994), because the samples of reviewed papers are different. Even so, from table 2 we can identify the difference existing between SCRM research and logistics and supply chain management research in terms of research methodology. For logistics and supply chain management research, survey method holds the highest position (Sachan and Datta, 2005). Nevertheless there are only 4.9% of the papers reviewed in our sample which apply survey method, the lowest percentage of all the methodologies applied. In 1995, Mentzer and Kahn represented that future logistics efforts needed to facilitate and manifest the maturation process toward greater rigor in study. "Greater rigour" means greater hypothesis testing, more rigorous data analysis, and standard discussion of validity and reliability. Mentzer and Kahn's conclusion is still suitable for nowadays SCRM research. Following the evolution route of logistics and supply chain management research, survey method would be a more import approach in SCRM research.

As illustrated by the percentages shown in table 2, 14.8% of all the papers fall in "interpretive/direct observation" paradigm, the number is approximate to Sachan and Datta's (2005) findings (16%). Sachan and Datta "believe that a much stronger movement toward naturalistic paradigms (especially direct observation via case, action, and field studies) and existential primary interpretive paradigms". Naslund (2002) also advocates more "action research case study". The research of SCRM is still at the early stage of evolution, case study and action research have special importance to describe risk characters, to develop concepts and testable hypotheses, as there are almost no prior hypnoses or previous work for guidance. Different supply chains may face different sorts of risks and individual enterprises must tailor particular mitigating tactics of risk control. On the other hand the case study methodology can bridge the gap between supply chain managers and academicians, and make authentic contributions to both academic research and management practice. Case study and action research will keep the position in SCRM research.

Table 2 shows that no paper of field experiment or field study based on direct observation was found in our review. Other form of experiment, simulation, has a percentage of 9.9%, is higher than Sachan and Datta's (2005) findings (5%), but less than Mentzer and Kahn's (1995) figure of 15%. It is difficult to do direct observation or experimentation work, but researchers can utilize simulation approaches to discover possible risk factors and risk consequences by imitating real-world situations and to assess whether the tactics of risk control are effective. Simulation is also carried out to check for validity of the models developed (Sachan and Datta, 2005). It is expected that simulation will have a higher percentage in SCRM research than that in normal logistics and supply chain management research.

b) Research Design Applied.

Research design applied means the type of paper whether it is based on empirical work or desk research and it can be divided into 5 categories: empirical quantitative, empirical qualitative, desk quantitative, desk qualitative and empirical triangulation (Sachan and Datta, 2005). From table 3 we can see that 67.9% of all are desk researches. Hence, it is obvious that more empirical research work is needed.

Research Design	Number	Percent

		(%)
Empirical quantitative	7	8.6
Empirical qualitative	13	16.0
Desk quantitative	33	40.7
Desk qualitative	22	27.2
Empirical triangulation	6	7.4
Total	81	100

Table 3 Research design applied

c) Main Contribution.

This dimension is used to analyse the inclination of research work to contribute to theory or pragmatism. The contribution means the orientation of research efforts can be: to serve academic purposes or to provide managerial implications. The research which aims to make academic contribution is always being conducted primarily to improve people's understanding of general issues without emphasis on its immediate applications. The academic contribution can be further divided into theory-testing or theory-generating contribution. Theory-testing means that an existing theory is applied to a new situation and its applicability is tested and validated or rejected. Meanwhile, theory-generating refers to efforts to construct new models or tools applicable to specific situations. Pragmatism refers to the approach towards serving practical or managerial purposes. On the other hand, research that does not attempt to benefit management directly to solve a specific existing problem is not considered pragmatic (Vafidis 2007). Table 4 presents the main contributions of reviewed papers based on the main contribution approach. Owing to increasing awareness among practitioners, 55.6% of related papers try to match the needs of practitioners by discussion on the practical method to control supply chain risks. Next 10 years scholars would conduct more deep academic researches on SCRM, especially on theory testing.

Contribution	Number	Percent
Theory generation	32	39.5
Theory Testing	4	4.9
Pragmatism	45	55.6
Total	81	100.0

Table 4. Main contribution of paper

d) Main Theories and Tools Applied.

Logistics is an application discipline and lacks a dominant theory foundation. It seems more likely that logistics always borrows theories from other subjects and will continue with this trend, and applies these to practical problems, rather than developing a theoretical base of its own (Vafidis 2007). For example, Choi and Krause (2006) observe "complexity" as a key area of managerial consideration and apply the literature on complexity to the supply base analysis. Tapiero (2007) gives a strategic collaborative approach to risk and quality control in a cooperative supply chain by using a Neyman-Pearson quantile risk framework for the statistical control of risks. Zsidisin and Ellram (2003) use the framework of agency theory in managing supplier behaviours as a mean to reduce supply risk and the impact of detrimental events. Kumar et al. (2008) exemplify how the Six Sigma DMAIC approach could be used to assist in the standardization of container security and help mitigate risks in supply chain design. Sinha et al (2004) provide a generic prescriptive methodology to mitigate supplier risk in the supply chain using the IDEF0 method; Tsai et al. (2008) combine transaction cost theory (TCT) and resourced based view (RBV) together to develop a qualitative risk model to empirically identify the important outsourcing risks of logistical functions using the data of Taiwanese retail chains. It is hopeful that these theories and analysis tools would be used in future research work or applications. The innovation of research needs new advanced theories and data processing techniques.

DISCUSSION

The literature review presented in this paper represents the initial step towards the development of a comprehensive conceptual model about supply chain risk management research.

CONCLUSIONS

The purpose of this study is to investigate the status of emerging SCRM research in the last 10 years in terms of methodologies applied, to develop a better understanding of the approaches applied in the research, the maturation process and to discuss implications for future research. It is hoped that the findings will facilitate future research by adding to the understanding of the characteristics and applicability of methodological choices. The empirical evidence used is based on 81 scientific papers found in the ABI/INFORM database which were published from 1999 to 2008. Methodological approaches were investigated by reading the papers and applying the frameworks shown in Table 1 to categorise the papers analysed. It can be seen that the status of SCRM research is in a pre-paradigmatic stage, in other words, SCRM research is in the early stages of evolution. The evolution would follow the similar route of supply chain management and logistics. To take the next step in the evolution process, the discipline of SCRM needs more theoretical contributions based on empirical data collection and rigorous research process. It is shown that SCRM research can be conducted using a multitude of different approaches. Survey scores the lowest among all the research methods used in SCRM research. There will be more research work about theory testing by survey method.

The development of a new discipline like SCRM is based on the usage of concepts, definitions, theories, rules and principles from other disciplines (Sachan and Datta, 2005). SCRM is the intersection of supply chain management and risk management theory. Supply chain is an authentic complex system due to its characteristics of multi-entity, multi-link, cross-region and compound structure and is easy to be affected by the unfavourable factors both from the outside environment and from the entities in the chain. It is necessary to borrow theories and tools from other discipline, or to innovate new theories and methods. But at present, typical theories and methods from other disciplines are applied in very few papers. Among the potential approaches to SCRM, the holistic approach is hopefully an effective way to theory generation and management practice.

There are limitations to this research but we are confident that status and trend of SCRM research indicated by the analysis is trustworthy. The number of SCRM papers published over the last 10 years has grown exponentially on a yearly basis and SCRM will continue to be a fertile research area. More and more talented academicians will contribute to those efforts. It is hoped that our findings would be useful for researchers who wish to obtain a general overview of the discipline in terms of research approaches and to select suitable research methodologies for their research works.

REFERENCES

Arbnor, I. and Bjerke, B., (1997) Methodology for Creating Business Knowledge, (Sage Publications: Newbury Park, CA).

Choi, T. Y and Krause, D. R. (2006) The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. Journal of Operations Management, Vol. 24, 5, pp. 637-652.

Dag Naslund, D. (2002) Logistics needs qualitative research - especially action research, International Journal of Physical Distribution & Logistics Management, Vol. 32, 5, pp. 321-338.

Dunn, S. C., Seaker, R. F., and Waller, M. A. (1994) Latent variables in business logistics research: Scale development and validation. Journal of Business Logistics, Vol. 15, 2, pp. 145-172.

Gammelgaard, B. (2004) Schools in logistics research? A methodological framework for analysis of the discipline. International Journal of Physical Distribution & Logistics Management, Vol. 34, 6, pp. 479-491.

Ganeshan, R., Jack, E., Magazine, M. J, and Stephens, P. (1999) A taxonomic review of supply chain management research. *In Quantitative Models for Supply Chain Management*, Edited by ayur, S., Ganeshan, R., and Magazine, M., PP. 839-879, (Kluwer Academic Publishers: Boston).

Hussey, J. and Hussey R. (1997) Business research: A practical guide for undergraduate and postgraduate students, (Macmillan Press: London).

Khan, O. and Burnes, B. (2007) Risk and supply chain management: creating a research agenda. International Journal of Logistics Management, Vol. 18, 2, pp. 197-216.

Kotzab, H., Seuring, S., Műller, M., and Reiner, G. (2005) Research methodologies in supply chain management (Physica-Verlag: Heidelberg).

Mangan, J., Lalwani, C., and Gardner, B. (2004) Combining quantitative and qualitative methodologies in logistics research. International Journal of Physical Distribution & Logistics Management, Vol. 34, 7/8, pp. 565-578.

Mentzer, J. T. and Kahn, K. B. (1995) A framework of logistics research. Journal of Business Logistics, Vol. 16, 1, pp. 231-250.

Meredith, J. R., Raturi, A., Amoako-Gyampah, K., and Kaplan, B. (1989), Alternative research paradigms in operations. Journal of Operations Management, Vol. 8, 4, pp. 297-326.

Norman, A., Jansson, U. (2004) Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. International Journal of Physical Distribution & Logistics Management, Vol. 34, 5, pp. 434-456.

Tang, C. S (2006) Perspectives in supply chain risk management. International Journal of Production Economics, Vol. 103, 2, pp. 451-488.

Kumar, S., Jensen, H., and Menge, H. (2008) Analyzing mitigation of container security risks using six sigma DMAIC approach in supply chain design. Transportation Journal, Vol. 47, 2, pp. 54-66.

Paulsson, U (2003) Managing risk in supply chains – an article review. Available online at: http://www.tlog.lth.se/detailpublication.asp?ID=155.

Sachan, A. and Datta. S. (2005) Review of supply chain management and logistics research. International Journal of Physical Distribution & Logistics Management, Vol. 35, 9/10, pp. 664-705.

Sinha, P. R., Whitman, L. E, and Malzahn, D. (2004), Methodology to mitigate supplier risk in an aerospace supply chain. Supply Chain Management: An International Journal, Vol 9, 2, pp.154-168.

Tapiero, C. S, (2007) Consumers risk and quality control in a collaborative supply chain. European Journal of Operational Research, Vol.182, 2, pp. 683-694.

Tsai, M., Liao, C., and Han, C. (2008) Risk perception on logistics outsourcing of retail chains: model development and empirical verification in Taiwan. Supply Chain Management: An International Journal, Vol. 13, 6, pp. 415-424.

Vafidis, D. (2007) Approaches for knowledge and application creation in logistics –An empirical analysis based on finnish and swedish doctoral dissertations published between 1994 and 2003, (Esa Print Tampere: Tampere, Finland).

Zsidisin, G. A and Ellram, L. M, (2003) An agency theory investigation of supply risk management. Journal of Supply Chain Management, Vol. 39, 3, pp. 15-27.

SECTION 5 – Supply Chain Dynamics and Inventory Management

VALUE BASED ORDER PRIORITIZING IN PRODUCTION CONTROL – INTEGRATING CUSTOMER VALUE MANAGEMENT INTO THE LOGISTICS GOAL-SETTING

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INTRODUCTION

Customer orders in international supply networks can have different importance due to e.g. various order sizes or customer values (Pardoe, Stone 2005). Thus, customer orders should be assessed and treated individually in order to distinct between more or less profitable ones, as creating superior customer value is a key element for companies' success (Huber, Herrmann & Morgan 2001, Laitamäki, Kordupleski 1997, Milgrom, Roberts 1995). One approach to evaluate customer orders is the Customer Value Management (CVM) (Helm, Günter 2006). This concept explicitly focuses on the financial impact of a specific customer order and analyzes the corresponding customer value (Stirling 2000). It aims for a maximum lifetime profit from the entire customer base (Pease 2001).

However, by implementing the CVM, the logistics goals of a system might be affected (Lummus, Vokurka 1999, Woodruff 1997). For example, if more important orders are prioritized over less important ones, the overall due date reliability of the company is likely to decrease as the prioritized orders interfere with the planned production sequence (Nyhuis, Wiendahl 2008). In consequence, the CVM has to be integrated with the logistics goal-setting in order to ensure both: matching logistics goals as well as prioritizing orders due to their financial importance (Martin 2005).

Current approaches of order prioritization do not integrate logistics goals (e.g. high due date reliability or high machinery utilization (Nyhuis, Wiendahl 2008)) with financial goals obtained by the CVM (maximum lifetime profit from the entire customer base (Pease 2001)). Hence, a comparability and prioritization for balancing different customer orders with respect to logistics and financial requirements is not possible. Therefore, the paper aims to develop a solution, which incorporates the financial and the logistics perspective by combining CVM and production control methods.

One approach in production logistics to deal with this challenge is the so-called autonomous product construction cycle (APCC). It applies the idea of autonomously acting smart objects, which are able to route their way through a production process according to their goals (Windt, Jeken 2009). The smart objects decide at each step of production. The idea is to base the decision not only on logistics goals but also on the customer value obtained by applying the CVM. Thus, the logistics goal-setting of each object can be weighted according to the specific customer order's value (Mentzer et al. 2001).

The overarching idea of this paper is to develop a prioritizing model for balancing logistics and financial requirements of customer orders in production control in order to rank different orders based on their importance. Thus, the aims are threefold: Firstly, logistics goals, financial goals, and their interrelations in production control will be described; secondly, causal relations between the CVM and the APCC will be identified; thirdly, a tool for prioritizing customer orders for a practical application will be deduced.
In the second section the relevance of logistics goals in production control as well as financial goals will be discussed in order to clarify possible interrelations and

requirements for developing a prioritizing model. In the third section, the concepts CVM and APCC will be introduced. Additionally, possible links between these concepts will be identified. Thus, the ideas of both concepts are attained and possibilities and limitations for their integration can be evaluated. Therewith, a basis for integration is established. Then, exemplary characteristics of customer orders are weighted by applying a scoring model and a pair-wise comparison. Consequently, the characteristics can be ordered according to financial and logistics goals. Finally, a prioritization of customer orders is deduced from the scoring values and integrated with the APCC. The fourth section outlines contributions and limitations of the introduced concept. Finally, the fifth section subsumes central findings and provides an outlook for further research.

MOTIVATION OF INTEGRATING LOGISTICAL AND FINANCIAL GOALS IN PRODUCTION CONTROL

The overarching goal setting of a company comprises strategic goals, which are according to Müller-Stewens and Lechner (2005) ensuring the survival of a company and creating and maintaining competitive advantages. Other goals like logistics as well as financial goals can be subsumed under this strategic goal setting (Lechner, Müller-Stewens 2005).

In logistics research, scientists attempted to identify Key Performance Indicators (KPIs) for measuring logistics goals (Shepherd, Günter 2006, Gunasekaran, Kobu 2007). While these surveys offer a comprehensive understanding of different logistics KPIs in general, Nyhuis and Wiendahl (2008) offer a condensed approach for production logistics KPIs by defining and integrating two logistics performance (due date reliability and throughput time) and two logistics cost targets (inventory level and machine utilization):

High due date reliability represents a company’s ability to deliver according to the confirmed delivery date and therefore contributes to the customer satisfaction. Short throughput times allow for quick responses to changes in demand as they represent the time span from order release till end of production. Low inventory levels are important to keep the capital tied up in stock as low as possible and contribute therefore to a company’s liquidity. High machine utilization contributes to a decrease of the fixed cost portion per unit. From a logistics point of view, these objectives can lead to reasonable prices and high customer service levels (Nyhuis, Wiendahl 2008).

Following Nyhuis and Wiendahl (2008), improving these KPIs with regard to their objectives, a logistics system’s target achievement can be enhanced. However, beside these KPIs, there are also other objectives like financial goals logistics systems strive for. In finance research, Smart, Megginson and Gitman (2004) introduced five functions of corporate governance financial managers have to take into account. Two of them directly follow the mentioned strategic goals ensuring survival (financial management function) and creating and maintaining competitive advantages (capital budgeting function) and are therewith the goals this paper focuses on.

The liquidity is a business ratio telling to what extend companies can use available liquidity potential for covering their existing liabilities. Therewith, a high liquidity indicates a high reliability according to serve liabilities (Wöhe 2008). Consequently, companies with a high liquidity can improve satisfaction of their stakeholders leading to a positive perception of a company among their stakeholders. This is important, since stakeholders form the relevant environment of a company (Lechner, Müller-Stewens 2005) and decide about its existence and success (e.g. a company obtains better ratios leading to cheaper credits from banks) (Hicks et al. 1975).

The profitability business ratio calculates the return of total capital employed for a specific investment (Wöhe 2008). This is important because the more profitable the more attractive a company is to investors, since they prefer investing into a more profitable company in order to obtain higher return (Wöhe 2008, Hilpisch 2005). Thus, acquiring new credits or getting other investment assets is facilitated and cheaper. Accordingly, investing into new strategies becomes possible for companies due to this enhanced financial flexibility. Moreover, profitability focuses on an optimal utilization of resources for obtaining competitive advantages (Lechner, Müller-Stewens 2005).

In conclusion, these goals cannot be considered separately, since they focus on two essential objectives of strategic management: potential to survive (liquidity) and ability to create competitive advantages (profitability) (Lechner, Müller-Stewens 2005). If a company fails only one objective, it is either unable to serve liabilities and becomes insolvent or it cannot create competitive advantages and will also become insolvent in the long run due to missing revenues.

In addition, the logistics and financial goals also cannot be regarded separately, since they affect each other. For example, one logistics goal is to minimize inventory in order to reduce tied capital (Nyhuis, Wiendahl 2008). This can cause a higher profitability, since lower inventory implicates fewer expenses (through less production or supplies), more earnings (through e.g. more sales decreasing inventory of finished products) or both. Accordingly, if the logistics goal to minimize inventory is fulfilled in a better manner, the financial goal profitability is also affected positively. Another example is the relation between liquidity and due date reliability. If the liquidity is negative, companies will receive a worse rating towards investors (e.g. banks) than with a higher liquidity (Hilpisch 2005). Thus, obtaining credits is hardened and consequently, required cash for investments into e.g. machinery cannot be paid. Hence, due date reliability might be decreased, since a new machine is required due to new requirements in production but it cannot be paid. Like these exemplary interrelations, there are also additional effects between logistics and financial goals. Hence, logistics goals and financial goals have to be considered integrated in order to achieve the best system performance.

According to e.g. Gunasekaran and Kobu (Gunasekaran, Kobu 2007), Shepherd and Günter (Shepherd, Günter 2006) or Neely et al. (Neely, Gregory & Platts 1995), there are actually different performance measurement approaches available for evaluating logistics systems and supply chain performance. However, criticisms of these existing approaches have been widely addressed in the performance management literature (e.g. Neely, Gregory & Platts 1995). The main criticisms are e.g.

- Lack of connection with strategy (Beamon 1999)
- Focus on cost to the detriment of non-cost indicators (Beamon 1999, De Toni, Tonchia 2001)
- Insufficient focus on customers and competitors (Beamon 1999) and
- Loss of supply chain context leading to local optimization (Beamon 1999).

Since this paper focuses on an integration of logistics and financial goals, existing approaches are inappropriate for an application, as they omit this integration of both perspectives in production logistics. Therefore, the paper strives for a new approach, which explicitly considers both a logistics and a financial perspective in production control.

A CUSTOMER-VALUE BASED CONCEPT FOR PRODUCTION CONTROL
The new approach of this paper comprises two concepts: one concept of production logistics (Autonomous Product Construction Cycle (APCC)) for covering logistics goals and one concept of marketing (Customer Value Management (CVM)) for covering financial goals.

Autonomous Product Construction Cycle
The complexity of nowadays logistics processes has significant impact on the performance of logistics processes in terms of delivery time and delivery reliability (Bozarth et al. 2009). In order to deal with these challenges one possibility could be to

increase the level of autonomous control of logistics processes (Scholz-Reiter, Windt & Freitag 2004). Autonomous logistics processes enable logistics objects (i.e. parts, containers) "to process information, to render and to execute decisions on their own" (Windt, Böse & Philipp 2008). For a typical job-shop manufacturing scenario, the idea of autonomous processes means that a part is capable to route itself through the production process.

The central idea of the APCC is that a part not only decides autonomously about the next production step, but takes also into consideration the available product variants and the placed customer orders. The decision method has to consider both, logistics criteria like throughput time as well as technological criteria like tools machine combination.

A product construction cycle spans from order release till product completion and refers to an incremental and variant oriented construction of the product; the adjective autonomous stands for a flexible and self-determined development of a product during its production cycle. For that purpose, a method was developed to provide each single item at any time with the situational product variant-customer order combination based on the current customer order pool. This loose allocation of manufactured products and confirmed customer orders represents an additional logistic flexibility potential and contributes to target achievement of the introduced logistics goals (Windt, Jeken 2009).

Various autonomous control methods have been proposed (Armbruster et al. 2006, Cicirello, Smith 2001, Scholz-Reiter et al. 2006), but none of them considers to evaluate different decision alternatives offered by the herewith proposed approach. A situational allocation of product variants and customer orders calls for an integrated evaluation of logistics and financial criteria related to different customer values. The APCC approach can integrate these different criteria, as it allows reallocating production orders due to their importance during the manufacturing cycle autonomously. To obtain the importance of a specific order, it has to be calculated based on financial ratios. Therefore, the CVM is applied, as it links single customer orders to the mentioned financial goals ensuring liquidity and maximizing profitability by increasing customer benefits or decreasing customer costs related to a single order, directly contributing to these financial goals.

Customer Value Management

The central idea of the CVM is that it treats each customer relationship with the goal of achieving maximum lifetime profit from the entire customer base. Therefore, revenues coming from customers should be increased and more frequent, whereas costs should be reduced and less frequent (Pease 2001). Thus and by focusing on single customers, the main goals of the CVM can be achieved, since (1.) the right customers can be identified (acquiring the customers who will be most valuable to the business), (2.) the right relationship can be established (customers who do don't receive the right touch or get too many conflicting offers lose rather than gain value), and (3.) the right retention towards customers can be kept (retaining the right customers, not every customer) (Pease 2001).

By achieving the goals of the CVM it can also contribute to the mentioned financial goals, since e.g. (1.) contributes to the profitability (most valuable customer creates the highest profit) and (3.) is conducive to the liquidity (only profitable customers will be served leading to increased liquidity). Consequently, managers should increase customer value in order to improve the target achievement of the financial goals. For increasing customer value, managers have two possibilities: increasing customer benefit or decreasing customer costs (Lechner, Müller-Stewens 2005). The customer benefit contains benefits a customer expects from a service or product. Customer costs comprise all costs related to a specific customer order based on activities between a customer and a company (Lechner, Müller-Stewens 2005). Thus, the customer value can be enhanced by adding e.g. new services (increase of customer benefits) or reduced by e.g. economies of scale (decrease of customer costs). In order to be able to rank specific customer orders, the underlying customer value has to be calculated based on specific parameters of customer benefits (e.g. frequency of order or revenue of orders) and customer costs (e.g. negotiation and production costs).

Integration of the Autonomous Product Construction Cycle and the Customer Value Management

There are two required steps for integrating the CVM and the APCC: first, the creation of a ranking according to the customer orders; second, release the order into the APCC.
In a first step, a ranking of orders based on the customer's value can be obtained by applying e.g. a scoring model (Geml 2008). The scores are obtained through different subsequent steps as shown in Figure 1:

I. Constitutive characteristics of customer benefits (e.g. frequency or revenue of orders) and customer costs (e.g. negotiation costs) are identified by e.g. analyzing orders or applying questionnaires. As one pre-condition, the concept demands for independent characteristics, since interdependencies between characteristics would make an appropriate weighting impossible (Geml 2008).
II. Weightings according to their importance are created by applying a pair-wise comparison (Geml 2008) of every characteristic with each other; the better a characteristic regarding target achievement (e.g. higher revenue and therewith higher liquidity) the higher its value. At first, the characteristics are entered into the upper right part of the matrix and then, they are compared to each other. If a characteristic in the top row contributes more to the financial goals than another in the second row, it obtains a 2, if both are equally important a 1, otherwise a 0. At last, the counter value is entered in the corresponding field in the lower left part (0 instead of 2 and 2 instead of 0, 1 remains the same).
III. Underlying customer orders are prioritized with regard to the obtained scores. All available orders will be compared to each characteristic. Thereby, a ranking will be built according to how a specific order matches these characteristics. The subsequent value in each cell is calculated as

$$\text{Cell Value} = \sum \text{Orders} - \text{Rank Order}_i \ \text{ with } 0 \leq i < \sum \text{Orders}$$

Finally, each Cell Value is multiplied with the SUM in Figure 1 of each characteristic in II. Thereby, the overall scoring of each customer order can be generated.

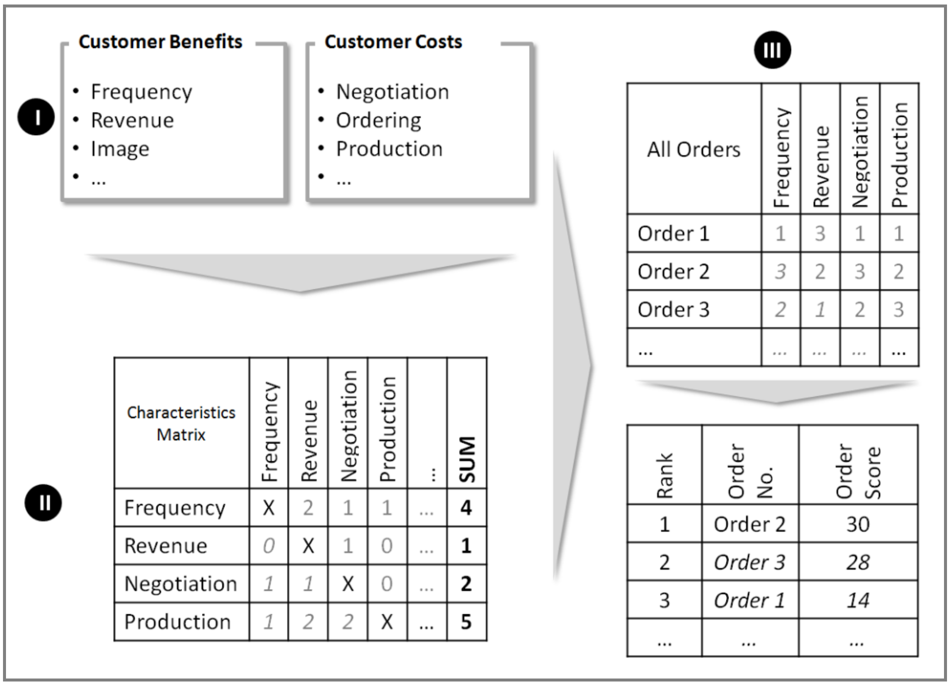

Figure 1: Pair-wise Comparison for building an Order Prioritization

In a second step, the obtained ranking shall then be released for production planning and control into the APCC. Taking the confirmed due date for the customer order and the derived rank of the customer order into account, a backward scheduling is conducted to determine the release date for the customer order. As the actual process plan of the part is not predetermined, a default process plan is composed based on the derived customer order ranks, in order to carry out the backward scheduling. The default process plan determines the sequence of operations and the selected work systems with their individual throughput time to perform the operations for the respective product, but becomes obsolete once the production has started.

In order to determine the individual throughput time of a specific work system, flow rate oriented scheduling can be applied (Nyhuis 2007). Flow rate oriented scheduling is based on the theory of logistics operating curves (Nyhuis, Wiendahl 2006), and allows to determine individual throughput times for specific work systems taking into consideration the work content of the operation, the capacities and the planned work in process level of the work system leading to a higher planning accuracy (Nyhuis 2007).

The resulting order release date allows starting production of the demanded product at the respective date and thereby initializing the autonomously controlled process. Once an order is released and production has started, the APCC logic takes control of the part. In order to route through the manufacturing cycle, the part, as an intelligent object, decides not only about the actual sequence of processing steps and the work systems to perform the steps, but it is also able to react to changes of customer orders. In case of quantity changes, parts reallocate themselves to serve the order with the highest rank. In case of due date changes requested by customers, the part also considers the rank of the order before reallocation. However, for all changes in product order allocation the trade-off between a higher prioritized order versus a lower prioritized order has to be positive in the sense of the CVM meaning that the re-adjusted ranking of the higher prioritized order is higher than the ranking of the lower prioritized order.

CONTRIBUTIONS AND LIMITATIONS OF THE INTRODUCED APPROACH

The following table gives a briefly overview about some selected contributions and deficits of the APCC, the CVM and the integrated approach of in this work:

Selected Contributions	Selected Limitations
Individual treatment of single orders Focus on important KPIs Integrated view of financial and logistical targets for production scheduling and control Connectivity to strategic management Consideration of cost-factors and non-cost factors	Simulation for proof of concept is missing Threat of local optima Cost-factors used in customer costs may change during production Non-cost factors hardly measurable Weightings of characteristics among single orders difficult

Table 1: Contributions and limitations regarding the introduced approach

The introduced concept treats each order individually enabling it to offer a high flexibility and customization. Therewith, matching new requirements for logistics like customization (Klaus, Kille 2008), can be improved. In addition, by focusing on important logistics KPIs (e.g. due date reliability), the design of an underlying system can be oriented on relevant target achievements. Consequently, the impact of short-term logistics KPIs can be linked to financial KPIs relevant for managing a company. Therewith, effects on the operational level of logistics can be estimated in the long run facilitating managers' decision rendering according to which customer order to serve. The reason is that their decisions' consequences can be estimated in a better manner through applying business ratios like the Cash-Flow or the Return on Investment. This concept also allows for a connection of operational logistics to the strategic management of a company by integrating logistics and financial goals, which helps closing the gap between the strategy of a company and its operations as addressed in section 2. Last, the concept of customer value management considers both cost-factors and non-cost factors, since it integrates e.g. image effects or negotiation costs via the customer benefits and customer costs respectively.

Beside the mentioned potential contributions of the introduced concept, there are some remaining deficits. First of all, a suitable simulation for a proof of concept is missing. Additionally, an empirical validation of the concept lacks as well. In conclusion, an application in practice may cause risks, since verification and validation are missing and stability of the concept has not been proofed. Resulting risks might be e.g. the threat of local optima, as the idea of the APCC implements the concept of autonomous control. Since parts in the APCC are autonomous, they follow their own goals. Hence, they might get stuck in local optima, as they do not know the global optima and once they achieved their goal they do not go for a further optimization. Beside the threat of local optima, another problem is that cost factors used in customer costs may change during production of a single order. Accordingly, the ranking obtained through the pair-wise comparison before and therewith the optimal production cycle may change. This is not considered in this concept so far. Furthermore, the customer benefits as well as customer costs may contain non-cost factors, which are difficult to measure. Consequently, a ranking can be built but estimating financial KPIs may be hardened, since these factors are difficult to determine exactly. Finally, obtaining suitable weightings of characteristics among single orders is complicated, since they may vary from company to company and depend on a company's strategy as well as on individual preferences of decision makers.

CONCLUSIONS

This paper intended to develop a prioritizing model for balancing logistics and financial requirements of customer orders in production control in order to rank different orders based on their importance.

The main contributions towards the described concept is the integration of an operational logistics perspective with its goals (high due date reliability, short throughput times, low inventory levels , high machine utilization) and a strategic financial perspective with its goals (ensuring liquidity and maximizing profitability) for production logistics. Furthermore, the application of the concept of autonomous control by utilizing the APCC enables the concept to cope with new requirements logistics systems are confronted with.

However, the concept has remaining limitations. At first, identifying relevant characteristics of customer orders is difficult and depends on various factors, which might differ from company to company. Furthermore, obtained characteristics have to be independent from each other (Geml 2008), what cannot always be guaranteed, since interrelations between specific characteristics might be unrevealed during identification. Moreover, the feasibility of the APCC logic for different manufacturing scenarios has to be studied in more detail, as different industries apply different manufacturing principles (e.g. flow production, job-shop production). Finally, the described threat of local optima has to be avoided by carefully designing and testing decision criteria in simulation studies.

Further research should focus on the remaining limitations. The next step could be the development and computation of a simulation model. Therefore, on the one hand software technologies have to be identified and perhaps advanced in order to implement, integrate and simulate the introduced concepts (APCC and CVM). On the other hand, due to the complexity and dynamics, essential problems like vulnerability against changes and non-predictability of the system behaviour persist and have to be investigated.

In conclusion, there are possible contributions of the introduced approach but they have to be out weighted carefully with the risks.

REFERENCES

Armbruster, D., de Beer, C., Freitag, M., Jagalski, T. & Ringhofer, C. 2006, "Autonomous control of production networks using a pheromone approach", Physica A: Statistical Mechanics and its applications, vol. 363, no. 1, pp. 104-114.

Beamon, B.M. 1999, "Measuring supply chain performance", International journal of operations and production management, vol. 19, pp. 275-292.

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.

Cicirello, V.A. & Smith, S.F. 2001, "Ant colony control for autonomous decentralized shop floor routing", Published by the IEEE Computer Society, , pp. 383.

De Toni, A. & Tonchia, S. 2001, "Performance measurement systems: models, characteristics and measures", International Journal of Operations and Production Management, vol. 21, no. 1/2, pp. 46-70.

Geml, R. 2008, Marketing- und Verkaufslexikon, Schäffer-Poeschel, Stuttgart.

Gunasekaran, A. & Kobu, B. 2007, "Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications", International Journal of Production Research, vol. 45, no. 12, pp. 2819-2840.

Helm, S. & Günter, B. 2006, "Grundlagen — Innovative Konzepte — Praktische Umsetzungen" in Kundenwert — eine Einführung in die theoretischen und praktischen Herausforderungen der Bewertung von Kundenbeziehungen, 3rd edn, Gabler, Wiesbaden, pp. 3-38.

Hicks, H.G., Gullett, C.R., Phillips, S.M. & Slaughter, W.S. 1975, Organizations: theory and behavior, McGraw-Hill.

Hilpisch, Y. 2005, Kapitalmarktorientierte Unternehmensführung: Grundlagen der Finanzierung, Wertorientierung und Corporate Governance, Gabler Verlag.

Huber, F., Herrmann, A. & Morgan, R.E. 2001, "Gaining competitive advantage through customer value oriented management", Journal of Consumer Marketing, vol. 18, no. 1, pp. 41-53.

Klaus, P. & Kille, C. 2008, Die Top 100 der Logistik: Marktgrößen, Marktsegmente und Marktführer in der Logistikdienstleistungswirtschaft, Deutscher Verkehrs Verlag, Hamburg.

Laitamäki, J. & Kordupleski, R. 1997, "Building and deploying profitable growth strategies based on the waterfall of customer value added", European Management Journal, vol. 15, no. 2, pp. 158.

Lechner, G. & Müller-Stewens, C. 2005, Strategisches Management: wie strategische Initiativen zum Wandel führen ; der St. Galler General Management Navigator, 3., aktualisierte Aufl. edn, Schäffer-Poeschel, Stuttgart.

Lummus, R.R. & Vokurka, R.J. 1999, "Defining supply chain management: a historical perspective and practical guidelines", Industrial Management and Data Systems, vol. 99, no. 1, pp. 11-17.

Martin, C. 2005, Logistics and Supply Chain Management: Creating Value Adding Networks, 3rd edn, Prentice Hall, Harlow.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. & Zacharia, Z.G. 2001, "Defining supply chain management", Journal of Business logistics, vol. 22, no. 2, pp. 1-26.

Milgrom, P. & Roberts, J. 1995, "Complementarities and fit strategy, structure, and organizational change in manufacturing", Journal of Accounting and Economics, vol. 19, no. 2-3, pp. 179.

Neely, A., Gregory, M. & Platts, K. 1995, "Performance measurement system design", International Journal of Operations and Production Management, vol. 15, no. 4, pp. 80-116.

Nyhuis, P. 2007, "Practical applications of logistic operating curves", CIRP Annals-Manufacturing Technology, vol. 56, no. 1, pp. 483-486.

Nyhuis, P. & Wiendahl, H.P. 2008, Fundamentals of production logistics: theory, tools and applications, Springer, Berlin.

Nyhuis, P. & Wiendahl, H.P. 2006, "Logistic Production Operating Curves-Basic Model of the Theory of Logistic Operating Curves", CIRP Annals-Manufacturing Technology, vol. 55, no. 1, pp. 441-444.

Pardoe, D. & Stone, P. 2005, "Bidding for customer orders in TAC SCM" in Agent-Mediated Eleectronic Commerce Springer, Berlin, pp. 143-157.

Pease, J. 2001, Customer Value Management - New Techniques for Maximizing the Lifetime Profitability of your Customer Base, Business Objects.

Scholz-Reiter, B., Freitag, M., de Beer, C. & Jagalski, T. 2006, "The Influence of Production Networks' Complexity on the Performance of Autonomous Control Methods", Intelligent Computation in Manufacturing Engineering 5. Proceedings of the 5th International Seminar on Intelligent Computation in Manufacturing Engineering, ed. R. Teti, University of Naples, Naples, pp. 317.

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.

Shepherd, C. & Günter, H. 2006, "Measuring supply chain performance: Current research and future directions", International Journal of Productivity and Performance Management, vol. 55, no. 3-4, pp. 242-258.

Smart, S., B., Megginson, W., L. & Gitman, L.,J. 2004, Corporate Finance, SmartFinance, Mason, USA.

Stirling, M. 2000, "Customer value management", Journal of Targeting, Measurement and Analysis for Marketing, vol. 9, no. 2, pp. 174-184.

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", 42nd CIRP Conference on Manufacturing Systems.

Wöhe, G. 2008, Einführung in die allgemeine Betriebswirtschaftslehre, Vahlen, München.

Woodruff, R.B. 1997, "Customer value: the next source for competitive advantage", Journal of the Academy of Marketing Science, vol. 25, no. 2, pp. 139-153.

FUZZY MULTI-OBJECTIVE VENDOR SELECTION FOR JIT PURCHASING

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ABSTRACT
This paper investigates JIT purchasing using a fuzzy multi-objective program for the vendor selection problem based on cost minimization, penalty minimization due to a violation of delivery schedule, and maximizing the quality level of the purchased quantity. Our model incorporates vendor-production capacity uncertainty to identify a penalty policy for vendors. A fuzzy AHP solution algorithm is proposed. A numerical example is presented, showing that decision makers prefer vendors with on-time delivery schedules than cost or quality.

1. Introduction

For manufacturers who subscribe to the Just-In-Time (JIT) system, parts and components deliveries are required to be "JIT" so that production will be uninterrupted and inventory level minimized. Suppliers to the JIT practitioners emphasize on timing and order quantity to ensure that their supply of parts feed the production line on time. To achieve this near continuous flow of parts, suppliers must align their delivery schedule with the buyer's production schedule. Chapman and Carter (1990) first explored the nature of JIT practice by studying the buyer-seller relationship, and concluded that shorter lead times and small lot sizes from the suppliers as well as strong supplier/customer linkages are important operating factors to reduce inventory levels. Gunasekaran (1999) characterized JIT purchasing as a small supplier base whose firms are located close to the buyer's plant, making frequent deliveries under a long-term partnership with the buyer. Indeed, the research on the vendor selection problem (VSP) is ongoing.

The methods used on the VSPs are mostly quantitative. Zimmerman (1986) used a basic linear weighting model to select the supplier with the highest overall rating. For instance, Chan et al. (2003) used the analytical hierarchy process (AHP) to select appropriate vendors using weighting processes. Pan (1989) used linear programming to determine the purchased quantities from various suppliers. Chaudhry et al. (1993) utilized a mixed-integer programming model to determine the order quantities from vendors offering cumulative or non-cumulative price breaks, albeit ignoring net price, delivery, quality and capacity in their evaluation criteria. Weber and Current (1993) applied a multi-objective programming model to allow buyers to analyze the trade off impacts among different purchasing strategies. Weber et al. (1998) further integrated the multi-objective model and a DEA model to implement a 'non-cooperative' strategy where negotiations with the vendors take place. System and policy constraints are utilized to represent the indirect and direct influence that the purchasing department can control.

As the information used in a VSP is sometimes imprecise, this information vagueness must be taken into consideration for any realistic VSP model building. Amid et al. (2006) first developed a Fuzzy Multi-Objective Programming (FMOP) model for a VSP incorporating information uncertainty and imprecision. The solution of Amid et al.'s model modifies Zimmermann's (1978) approach by applying unequal weighting coefficients to represent the relative importance among the fuzzy objectives and fuzzy constraints. A crisp single objective programming is formulated and solved to yield the equivalent solution for the FMOP model. In this paper, we modify the fuzzy multi-objective mixed-integer programming model from Amid et al. (2006) for the VSPs employed in JIT purchasing. A solution algorithm is proposed to solve the model by incorporating a fuzzy AHP approach.

The rest of the paper is organized as such. Section 2 presents the development of the FMOP model. Section 3 details the solution algorithm. Section 4 illustrates a numerical example to demonstrate the application of the proposed FMOP model. Section 5 concludes.

2. Fuzzy multi-objective vendor selection model for JIT purchasing

Under JIT purchasing, a vendor focuses on delivery punctuality and product quality so that the purchased parts can be received on time and be processed immediately. We basically adopt the vendor evaluation process of Weber et al. (1991) using the five evaluation criteria of quality, delivery, net price, geographical location and production capacity for vendor selection and purchase order quantity. The following notations are used for our model:

Decision Variables:

1. Q_{ij}: Number of units of part *i* supplied by vendor *j*.
2. X_{ij} : 0-1 variable determined by whether part *i* is supplied by vendor *j* (=1 if supplied).

Parameters:

1. C_j : Capacity of vendor *j*.
2. Cp_{ij} : Fixed cost due to purchasing part *i* from vendor *j*.
3. Cq_{ij}, Cf_{ij}: Unit cost of inspection, and unit cost of failure for part *i* supplied by vendor *j*.
4. c_{ij} : Unit cost of purchasing part *i* from vendor *j*.
5. D_i : Total demand for part *i*.
6. E_{ij}, L_{ij}: Earliest delivery date (EDD), latest delivery date (LDD) for part *i* from vendor *j*.
7. l_{ij} : Lead time for part *i* delivered by vendor *j*.
8. LE_{ij} : Lower bound for the EDD for part *i* from vendor *j*. No delivery is allowed prior.
9. UL_{ij} : Upper bound for the LDD for part *i* from vendor *j*. No delivery is allowed after UL_{ij}.
10. Ce_{ij} : Unit penalty cost initiated if part *i* is delivered between LE_{ij} and E_{ij} by vendor *j*.
11. Cl_{ij} : Unit penalty cost initiated if part *i* is delivered between L_{ij} and UL_{ij} by vendor *j*.
12. q_{ij} : Percentage of defective parts for part *i* supplied by vendor *j*.
13. m_{ij} : Minimum order quantity for part *i* required by vendor *j*.

We assume that a buyer requires multiple parts that can be sourced from multiple vendors: a part can be bought from several vendors as long as the selection criteria are satisfied. Each criterion contributes partial performance measures that are eventually aggregated into the model's objective function. Further, some criteria are used to form the model constraints so that the feasible region can be located. With this, a linear model with three objective functions is formulated, of which Z_1 and Z_3 are minimization objectives where Z_1 represents the total cost and Z_3 is the penalty due to a violation of delivery schedule. Z_2 is a maximization objective that is used to maximize the quality level.

$$\text{Min } Z_1 = \sum_i \sum Q_{ij} c_{ij} + \sum_i \sum_j X_{ij} Cp_{ij} \quad (1)$$

Max $Z_2 = \sum_i \sum_j Q_{ij}\left(1 - q_{ij}\right)$ (2)

Min $Z_3 = \sum_i \sum_j Q_{ij} Ce_{ij}\left(E_{ij} - l_{ij}\right) + \sum_i \sum_j Q_{ij} Cl_{ij}\left(l_{ij} - L_{ij}\right)$ (3)

Subject to

$\sum_j Q_{ij}\left(1 - q_{ij}\right) = D_i$ for all *i* (4)

$Q_{ij} \leq C_{ij}$ for all *i, j* (5)

$\sum_i Q_{ij} \leq \sum_i X_{ij} C_{ij}$ for all *j* (6)

$Q_{ij} \geq m_{ij} X_{ij}$ for all *i, j* (7)

$X_{ij} l_{ij} \leq UL_{ij}$ for all *i, j* (8)

$X_{ij}(l_{ij} - LE_{ij}) \geq 0$ for all *i, j* (9)

$Q_{ij} \leq MX_{ij}$ for all *i, j* (10)

$Q_{ij} \geq 0$ for all *i, j* (11)

$X_{ij} \in \{1,0\}$ for all *i, j* (12)

Constraint set (4) enforces the fulfillment of the demanded quantity for each part. Constraint set (5) serves as the capacity constraint for each vendor and set (6) as overall capacity restriction. Constraint (7) specifies the minimum order quantity for all vendors. Constraints in set (8) limit the maximum lead time for each part supplied by all vendors and set (9) restricts the lead time to no earlier than the lower bound of the earliest due date. Constraints in set (10) can prevent a conflict of the decision variables. Constraint set (11) preserves the non-negativity and set (12) the integrality on the decision variables.

Since the information regarding the VSP is fuzzy in nature, the original model is transformed to an FMOP model to tackle the VSP. The FMOP model, reformulated from the crisp model and modified from the fuzzy vendor selection model developed by Amid et al. (2006) is shown below. To avoid triviality, only those constraints with fuzziness are shown here. The deterministic constraints (6)-(12) remain unchanged.

Min $Z_1 \cong \sum_i \sum Q_{ij} c_{ij} + \sum_i \sum_j X_{ij} Cp_{ij}$ (13)

Max $Z_2 \cong \sum_i \sum_j Q_{ij}\left(1 - q_{ij}\right)$ (14)

Min $Z_3 \cong \sum_i \sum_j Q_{ij} Ce_{ij}\left(E_{ij} - l_{ij}\right) + \sum_i \sum_j Q_{ij} Cl_{ij}\left(l_{ij} - L_{ij}\right)$ (15)

Subject to

$\sum_j Q_{ij}\left(1 - q_{ij}\right) \cong D_i$ for all *i* (16)

$$Q_{ij} \tilde{\leq} C_{ij} \qquad \text{for all } i, j \tag{17}$$

3. Solution algorithm for FMOP model

To solve the FMOP model, we adopt Amid et al.'s (2007) solution algorithm as follows:

1. Defuzzicate the fuzzy capacity constraints by a weighted average approach.
2. Solve the problem as a single objective problem for all objective functions. For each objective function, find the upper and lower bound solutions using Zimmerman's (1978) max-min approach.
3. Find the respective membership functions for all objective functions and fuzzy demand constraints.

The membership functions $\mu_i(x_i)$ for the three fuzzy objective functions and fuzzy demand constraints are given below. L_1, L_2, and L_3 denote the lower bounds for the three fuzzy objective functions while U_1, U_2, and U_3 are the upper bounds. Also, l_i and u_i denote the lower and upper bounds respectively of the demand constraint for part *i*.

$$\mu_1(Z_1(x)) = \begin{cases} 1 & \text{if } Z_1(x) \leq L_1 \\ \dfrac{U_1 - Z_1(x)}{U_1 - L1} & \text{if } L_1 \leq Z_1(x) \leq U_1 \\ 0 & \text{if } Z_1(x) \geq U_1 \end{cases} \tag{18}$$

$$\mu_2(Z_2(x)) = \begin{cases} 1 & \text{if } Z_2(x) \geq U_2 \\ \dfrac{Z_2(x) - L_2}{U_2 - L_2} & \text{if } L_2 \leq Z_2(x) \leq U_2 \\ 0 & \text{if } Z_2(x) \leq L_2 \end{cases} \tag{19}$$

$$\mu_3(Z_3(x)) = \begin{cases} 1 & \text{if } Z_3(x) \leq L_3 \\ \dfrac{U_3 - Z_3(x)}{U_3 - L_3} & \text{if } L_1 \leq Z_3(x) \leq U_3 \\ 0 & \text{if } Z_3(x) \geq U_3 \end{cases} \tag{20}$$

$$\mu_i(C_i(x)) = \begin{cases} 1 & \text{if } C_i(x) \geq u_i \\ \dfrac{C_i(x) - l_i}{u_i - l_i} & \text{if } l_i \leq C_i(x) \leq u_i \\ 0 & \text{if } C_i(x) \leq l_i \end{cases} \tag{21}$$

4. Find the decision preferences for the objective functions and constraints using fuzzy AHP. The method proposed by Buckley (1985) is used to find the weights for fuzzy AHP.
5. Reformulate the FMOP model as a crisp single objective model by using results obtained from steps 2 to 4.

A weighted crisp single objective model as proposed by Amid et al. (2006) is modified and used to solve the FMOP model, where w_k and γ_r denote the achievement level of the objectives and constraints respectively. There are *K* objectives and *R* constraints.

$$\text{Max } \sum_{k=1}^{K} w_k \lambda_k + \sum_{r=1}^{R} \Omega_r \gamma_r \tag{22}$$

Subject to

$$\lambda_k \leq \mu_k(Z_k(x)) \qquad k = 1,2,\ldots K \tag{23}$$

$$\gamma_k \le \mu_r(C_r(x)), \qquad r = 1,2,\ldots R \tag{24}$$

$$\sum_i Q_{ij} \le \sum_i (w_1 C^p_{i,\beta} + w_2 C^m_{i,\beta} + w_3 C^o_{i,\lambda}), \quad i = 1,2\ldots,n \tag{25}$$

$$\sum_i b_{si} Q_{ij} \le d, \qquad s = 1,2\ldots m \tag{26}$$

$$\lambda_k, \gamma_r \in [0,1], \qquad k = 1,2\ldots K, \; r = 1,2,\ldots R \tag{27}$$

$$\sum_{k=1}^{K} w_k + \sum_{r=1}^{R} \Omega_r = 1, \quad w_k, \Omega_r \ge 0 \tag{28}$$

$$Q_{ij} \ge 0, \qquad i = 1,2,\ldots n \tag{29}$$

6. Find the optimal solutions for the single objective model in step 5.

4. Numerical example

To show the application of the proposed FMOP model, consider a Taiwanese stereo manufacturer practising JIT production with parts needed for the production of a specific type of microphone purchased from several vendors. In this case, four types of electronic parts are supplied by five potential vendors. The expected demands for each part are 1000, 1200, 2000, and 1500 respectively. These demands must be fulfilled and extra parts will not be received so that inventory level is minimized. The minimum order quantity imposed by each vendor is 120, 180, 220, 260 and 200 respectively. The production capacities of the five vendors are known with imprecise information. This capacity uncertainty is represented as a triangular fuzzy number with pessimistic, most likely, and optimistic values. Table 1 illustrates the fuzziness of each vendor's production capacity. The quality level for each part is different according to the vendor's production capability (see Table 2). Therefore, various quality costs are incurred as shown by Table 3. Due to space constraint, Tables 1-3 are available from the authors on request.

Vendors must deliver the specified quantity of parts within specified time windows. Penalties are incurred when delivery agreements are violated. The expected lead times and associated time windows as well as the incurred penalties are given in Table 4. The time window for each part is set to one day (e.g., L_{i1}-E_{i1}=17-16=1 for part 1) to represent a tighter delivery schedule for JIT buyers. The schedule is relaxed with a two-day (e.g., E_{i1}-LE_{i1}= 16-14= 1 and UL_{i1}-L_{i1} = 19-1.7 = 1) conditional grace period albeit with penalty. It is noted that the delivery lead time of vendor 1 for part 3 is earlier than the lower bound of the earliest delivery date ($l_{31}=7 < LE_{31}=8$) and the lead time of vendor 2 for part 1 is later than the upper bound of the latest delivery date ($l_{12}=20 > UL_{12}=19$). Since the vendor lead times are not known precisely, the triangular fuzzy number is assumed to represent the uncertainty in lead time. Table 5 shows the triangular fuzzy numbers for lead times with respect to each vendor and the defuzzication is depicted in Table 6. Due to space constraint, Tables 4-6 are available on request from the authors.

Step 1: Defuzzicate fuzzy capacity constraint. We defuzzicate the capacity constraints by using the weighted average approach i.e. the weight of the most likely is 4/6, and the weights of optimistic and pessimistic are 1/6 and 1/6 respectively. The defuzzicated capacities are 1442, 1400, 1650, 1617, and 1583 for the five vendors respectively.

Step 2: Solve a single objective function model using Zimmermann's (1978) max-min approach for each objective function of the FMOP model. The results are as follows: (Z_1, Z_2, Z_3) = ({17364, 23433}, {5700,6932}, {152, 1320}) where {x,y} denote {min, max}.

Step 3: Find the associated membership functions for the fuzzy objective functions and the fuzzy demand constraints. The membership functions are given by the upper and lower bounds obtained in Step 2 while the membership functions for the fuzzy demand constraints are found from the imprecise demand information for each part (see Table 7). Due to space constraint, Table 7 is available on request from the authors.

Step 4: Use fuzzy AHP to find the decision preferences for the objective functions and constraints. A questionnaire on the pairwise comparisons among the different objective functions and demand constraints are constructed and delivered to 20 experienced purchasing managers and senior procurement engineers of the stereo industry in Taiwan. The aggregated fuzzy pairwise comparison matrix is given in Table 8. Due to space constraint, Table 8 is available on request from the authors.

The geometric mean fuzzy weight proposed by Buckley (1985) is implemented to calculate the weights of the preference among the objectives and demand constraint. Take Z_1 (cost minimization), for example,

L = $\sqrt[4]{1\times(1/8)\times(1/6)\times 2} = 0.452$, M = $\sqrt[4]{1\times(1/7)\times(1/5)\times 3} = 0.541$, & R= $\sqrt[4]{1\times(1/6)\times(1/4)\times 4} = 0.639$. Hence r_1=(0.45, 0.54, 0.64). Similarly, r_2=(3.81, 4.28, 4.74), r_3=(1.23, 1.43, 1.64), and r_4=(0.26, 0.30, 0.37). $r_1 \oplus r_2 \oplus r_3 \oplus r_4 = (5.75, 6.55, 7.38)$. Thus $(r_1 \oplus r_2 \oplus r_3 \oplus r_4)^{-1} = (0.174, 0.153, 0.135)$. $\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \cdots \oplus \tilde{r}_m)^{-1}$. Therefore, the weight of Z_1 can be obtained as follows: $\tilde{w}_1 = (0.452, 0.541, 0.639) \otimes (0.174, 0.153, 0.135) = (0.061, 0.083, 0.106)$

The defuzzicated value of the weights can be computed using $DF = [(R-L)+(M-L)]/3+L$. Therefore, the crisp value of w_1 =0.083. Similarly, the defuzzicated weights can be obtained and are summarized in Table 9 (available from the authors on request).

Steps 5 and 6: Reformulate the FMOP model as a crisp single objective model. Find the optimal solution. The single objective model is solved using LINGO on a Pentium IV (3.2GHz) personal computer. The results are shown in Table 10. Due to space constraint, Table 10 is available on request from the authors.

The results show that the achievement level of the on-time objective (λ_3) is greater than the achievement level of the other two objectives. The rankings of achievement levels among objectives are found to be inconsistent with the results of the objective preferences obtained from the implementation of the fuzzy AHP. In short, the decision makers prefer vendors with on-time delivery schedules. The use of the proposed time-windowed vendor selection model restricts the buyer from purchasing parts from vendors unable to meet the delivery time window. Hence, the trade-off between the penalty for violating the soft time window and the other cost terms such as the cost of purchasing, transportation and quality affects the decision of vendor selection and order allocation.

CONCLUSION

This paper studies the problem of vendor selection for a buyer using a JIT system with imprecise information. We apply an FMOP model to determine the selection of vendors as well as the associated order quantity from each selected vendor, and to identify an appropriate penalty policy for vendors and other performance measures such as delivered quantity, quality, and related part attributes. This allows a buyer to adjust the window width according to the degree of urgency or need for parts delivery. Integrating multiple criteria for vendor selection requires a more dynamic evaluation process. The model parameters must be chosen carefully under a thorough data analysis and be updated continuously so that quality decisions can be made. However, the uncertainty along the entire supply chain further complicates the evaluation process. For JIT practitioners, supply line interruptions caused by time related uncertainty are intolerable. Thus, a tighter time window along with greater time violation penalty is suggested for managing the vendor selection problem.

REFERENCES

Amid A, Ghodsypour SH & O'Brien C (2006), "Fuzzy multiobjective linear model for supplier selection in a supply chain", *International Journal of Production Economics*, *104*, 2, 394-407.

Buckley JJ (1985), "Ranking alternatives using fuzzy numbers", *Fuzzy sets and Systems*, *15*, 21-31.

Chan LM, Muriel A, Shen Z-J, Simchi-Levi D & Teo C-P (2002), "Effective zero-inventory-ordering policies for the single-warehouse multiretailer problem with piecewise linear cost structure", *Management Science, 48*, 1446-1460.

Chapman SN & Carter PL (1990), "'Supplier/customer inventory relationships under just in time", *Decision Sciences, 21*, 35-51.

Chaudhry SS, Forst FG & Zydiak JL (1993), "Vendor selection with price breaks", *European Journal of Operational Research, 70*, 52-66.

Gunasekaran A (1999), "Just-in-time purchasing: an investigation for research and application", *International Journal of Production Economics, 59*, 77-84.

Pan AC (1989), "Allocation of quantities among suppliers", *Journal of Purchasing and Materials Management, 25*, 36-39.

Weber CA, Current JR & Benton WC (1991), "Vendor selection criteria and methods", *European Journal of Operational Research, 50*, 2-18.

Weber CA & Current JR (1993), "A multiobjective approach to vendor selection", *European Journal of Operational Research*, *68*, 173-184.

Weber CA, Current JR & Desai A (1998), "Non-cooperative negotiation strategies for vendor selection", *European Journal of Operational Research, 108*, 208-223.

Zimmermann H-J (1978), "Fuzzy programming and linear programming with several objective functions", *Fuzzy Sets and Systems*, *1*, 45-55.

Zimmermann H-J (1986), *Fuzzy Sets Theory and Its Applications*, 2nd ed., Boston: Kluwer-Nijhoff Publishing.

APPLICATION OF LEAN THINKING IN MANUFACTURING: A SURVEY OF SMALL AND MEDIUM-SIZED ENTERPRISES IN CHINA

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ABSTRACT
Through a questionnaire survey, this paper reports the findings on the current status of lean thinking adoption by the small- and medium-sized manufacturers in China. The findings suggest that application of lean thinking is not widespread. For those firms that have adopted lean thinking, the major benefits obtained are reduction in cost and waste, inventory, labour, and cycle time. The major difficulties encountered are communication between workers and managers, and collaboration with supply chain members.

INTRODUCTION

Efficiency and responsiveness can be regarded as the primary goals in supply chain management (SCM) (Chopra & Meindl 2010). To achieve these two objectives, waste elimination and flexibility enhancement are the keys. They help reduce operating cost and enforce continuous improvement thereby increase overall efficiency and responsiveness. With growing recognition of the significance of SCM, the notion of "lean supply chain" – a derivative of "lean thinking" (Womack & Jones 2003) – has been proposed. Application of lean thinking in SCM has been witnessed all over the world. In the UK, many food and farming supply chains have applied lean thinking (Cox & Chicksand 2005). In the US, companies such as Buck Knives, New Balance Athletic Shoe, and Ariens Co. have enjoyed improvement brought by lean management (Kator 2007). As consumer markets become increasingly competitive, unpredictable, and volatile in recent years, cost minimization, flexibility, and resources optimization are the strong incentives for supply chain members to adopt a lean approach.

Although lean thinking has been applied in many supply chains such as those for wood, beef, and apparel products (Cox & Chicksand 2005; Czabke et al. 2008), the outcome is not always as good as anticipated. Many of the expected benefits of lean management, which include lower inventories, reduced space, shorter lead time, flexible response to customers, improved quality, and smoother flows of materials and information, have not been witnessed (Parks 2002). While there are many studies on lean production and lean manufacturing particularly in the design of factory layout or manufacturing process, relatively few researches have been conducted relating to the challenges in applying lean thinking in SCM. As SCM covers all the activities in a supply chain instead of solely manufacturing, failure to understand accurately the concept of lean thinking, to identify correctly the right areas to apply, or to recognize properly the challenges in applying will unlikely lead to total success.

With keen competition from other fast developing countries such as Vietnam and Mexico, China, currently being the world's largest manufacturing base, has to improve her performance in the global supply chain in order to maintain her competitive edge. It is therefore critical for the manufacturers in China, particularly the small- and medium-sized enterprises that constitute the majority of the production force, to derive benefits from lean thinking in order to remain competitive. In this regard, few studies have been done to explore the benefits and challenges of lean thinking application in SCM particularly from the manufacturers' perspective (Taj 2008). To fill the gap in the literature, this study attempts to investigate the current status of application of lean thinking by the small and medium-sized manufacturers (SMMs) in China. The following research questions are raised:

Q1 – What is the understanding of lean thinking in SCM to the SMMs in China?

Q2 – To what degree and how good have the SMMs in China applied lean thinking in their SCM?
Q3 – What are the benefits, if any, and challenges to the SMMs in China in applying lean thinking in SCM?

To answer the above research questions, this study used a questionnaire survey to collect data on the current status of lean thinking adoption by the SMMs in China. Views of the surveyed SMMs on the benefits and challenges they enjoyed and encountered were also gathered. The aim is to investigate the significance of the various considerations, such as waste reduction, quality improvement, flexibility enhancement, implementation cost, management commitment, collaboration with supply chain members, etc. on the decisions of the firms to adopt lean thinking. Similarity of these considerations with those identified in the literature are compared and discussed.

LITERATURE REVIEW

The term "lean thinking" was first introduced by Womack and Jones in 1996 (Womack & Jones 2003). It is basically an offset of muda – a Japanese word which means "waste". So far, there is no consensus on the definition of "lean". Many publications and studies have interpreted leanness as manufacturing or producing with less resources and waste (Browning & Heath 2009; Taj 2008). Some have extended its meaning to a broader range covering changes in work design and employee empowerment (Mehta & Shah 2005). In the context of manufacturing, "lean production" is defined as producing without muda or waste. There are generally seven types of waste which include overproduction, waiting time, transportation, inventory, processing, motion, and defects (Taj, 2008). An eighth waste – the waste of design – was added by Womack and Jones (cited in Wood 2004). Although lean thinking may prevent some SMMs from achieving their primary competitive advantage of being flexible, it is important to note that the goal of being lean is not doing everything with absolute minimum amount of resources such as zero inventories. Some additional processes and resources to enhance flexibility and responsiveness will increase the overall value when the market is uncertain and instable (Browning & Heath 2009). The important thing is to strike an appropriate balance between cost reduction and value creation. As such, value is usually the criterion used to judge whether an activity is a waste or not (Womack & Jones 2003). In applying lean thinking, Womack and Jones (2003) propose five principles in (1) specifying value; (2) identifying entire value stream; (3) ensuring the products flow continuously; (4) supplying when customers pull value; and (5) looking for perfection.

In recent years, studies of SCM have shifted from a narrow operation management point of view to a broader total SCM perspective (Burgess et al 2006). Given the many benefits of being lean, application of lean thinking in SCM is worthy of consideration. Being lean improves the competitiveness of a company. As reported in the literature, the strengths of lean thinking can be broadly divided into three main types: (1) manufacturing improvement (e.g., low inventories, fewer damages); (2) financial performance improvement (e.g., more profit); and (3) human resources improvement (e.g., optimization of labour usage).

There are also barriers to the application of lean thinking reported in the literature. These obstacles can generally be divided into two groups: (1) challenges in implementation; and (2) challenges in performance. The former includes communication between workers and managers as well as communication between supply chain members and the focal company. The latter refers to the lower-than-expected outcome upon application of lean thinking which can be due to high implementation cost (Browning & Heath 2009). Some also consider that reduction of stocks and labours may make the supply chain less flexible in responding to the market (Fearne & Folwer 2006).

Despite an early introduction of lean thinking to the automobile industry in China in the late 1970s by Taiichi Ohno, the originator of Toyota production system, China is lagged behind in the application of lean thinking in SCM. There are relatively few studies on lean thinking even in the area of lean production. Taj (2008) surveyed 65 manufacturing plants in China and found a dramatic gap between the lean target and the existing operation. Although many companies in developed countries are outsourcing their manufacturing functions to China because of her cheap labour supply, growing competitions from other developing countries such as Vietnam and Mexico and increasing labour cost have urged the Chinese manufacturers to reconsider the old neglected philosophy of lean thinking. Reports of some successful cases of lean thinking application in SCM have also attracted the attention of manufacturers to the benefits that could be brought about by applying lean thinking.

METHODOLOGY

This study used a self-administered questionnaire survey to collect data for analysis. According to the National Bureau of Statistics of China (2005), there are over 1.3 million manufacturers, large and small, in various industries in the country. Therefore, the total number of SMMs should be in hundreds of thousands. In this study, the target population is all SMMs in the Yangtze Delta region employing 2000 or fewer workers regardless of industry. The Yangtze Delta region is the richest and most densely populated city cluster in China (including Shanghai, Nanjin, Suzhou, Wuxi, etc.) where many SMMs are located. Therefore, it is believed that a sample selected from this region should be more representative than that from other region.

A list of SMMs in the Yangtze Delta region was first compiled from a Yellow Page entitled China SME Information Network. To ensure an even coverage of industries, a stratified random sampling method was used. Approximately 20 SMMs in each industry were selected at random contributing to a total sample of 1000 companies. Internet search was then conducted to obtain the up-to-date contact e-mail addresses of the selected firms. Questionnaires were sent by e-mail to the selected companies and returned by e-mail upon completion. Reminders were also used to encourage response. The survey was conducted and completed in October/November of 2009. A total of 31 valid responses were gathered with a response rate of about 3%. The low response rate is believed to be due to the fact that very few SMMs in China have applied leaning thinking in production or SCM as revealed in the literature review. For those SMMs that have not applied lean thinking, they might not bother to respond at all.

To facilitate response, close-ended questions are asked in the questionnaire. There are a total of 14 questions investigating the understanding of lean thinking and eliciting views of responding companies on the various benefits and challenges to lean thinking application in SCM as identified in the literature. Part A of the questionnaire (with 4 questions) collects background information of the company and the industry to which it belongs. Part B (with 2 questions) investigates the respondent's understanding of the lean thinking concept and whether the organization has applied lean thinking. For firms that have applied the concept, Part C (with 4 questions) examines the areas to which lean thinking has been applied and the result of the application. Respondent is also asked about the benefits the company has enjoyed and the challenges it has faced in applying lean thinking. For firms that have not applied lean thinking but are considering doing so, Part D (with 3 questions) explores the potential areas of application and the perceived benefits and challenges. Finally, for those firms that do not consider applying lean thinking at all, Part E (with 1 question) investigates the reasons for not considering. A five-point Likert scale ranging from 1 (the worst) to 5 (the best) is used to gauge the result of lean thinking application. Pearson chi-square test and one-sample *t*-test were used to analyse the data.

FINDINGS AND DISCUSSION

Profiles of Companies Surveyed

Owing to the relatively small number of valid returns, the sample is only subdivided into two groups in most of the analyses. Among the 31 companies surveyed, 18 are small-sized manufacturers with less than 500 employees. The remaining 13 are medium-sized manufacturers with 500 to 2000 employees. About half of the companies (15 out of 31) are electronic product or household appliance manufacturers while the others are in various industries. Out of the 31 companies surveyed, 15 have applied lean thinking. The adoption rate is therefore 48.4%. The rest are either investigating the possibility (7 firms) or not considering at all (9 firms). About one-third of the respondents (11 out of 31) are holding senior management positions such as chairman, CEO, managing director, or department manager of the company. Therefore, it can be assumed that their views reflect truly the current attitudes or considerations of their companies in lean thinking application.

Propensity to Apply Lean Thinking

Chi-square tests were run to determine if lean thinking application depends on firm size and/or industry type. The test results suggest that there is a positive association between propensity to apply lean thinking and firm size (Table 1). The correlation coefficients *C* and *V* are both around 0.3 indicating that the association is a moderate one. Therefore, we can reject the null hypothesis of no association and conclude that medium-sized manufacturers are more receptive to the concept of lean thinking and show a stronger tendency to apply. However, there is not enough evidence to suggest any association between propensity to apply lean thinking and industry type. Therefore, we cannot reject the null hypothesis of no association and can only conclude that manufacturers of different industries are equally likely to apply lean thinking.

Table 1 χ^2 test for association between propensity to apply lean thinking and firm size

	Small-sized firms	**Medium-size firms**	**Total**
Application of lean thinking			
Applied	6	9	15
Not applied	12	4	16
Total	18	13	31
Chi-square test			
Calculated χ^2 value	3.895		
Degree of freedom	1		
Critical χ^2 value at $\alpha = 0.05$	3.841		
p-value	0.048	$\therefore$ Reject H_0	
Correlation coefficients			
Contingency coefficient *C*	0.334		
Cramér's *V*	0.354		

H_0 : There is no association between propensity to apply lean thinking and firm size.

H_A : Propensity to apply lean thinking and firm size are positively associated.

Understanding of Lean Thinking

To the surveyed manufacturers, lean thinking mainly refers to waste reduction in production hence cost cutting. Table 2 shows that these two views are chosen by most manufacturers (some of which have chosen more than one view). The other popular opinion is that lean thinking is a set of principles used to manage production process. In comparison, only a few manufacturers have related lean thinking to SCM implying that lean thinking is still very much regarded by the manufacturers as something to do with production. Chi-square tests reveal no association between the understanding of lean thinking and firm size or industry type suggesting that the views are quite consistent.

Table 2 Understanding of lean thinking based on firm size and industry type

Perception of lean thinking	**Firm Size**			**Industry Type**		
	Small	Medium	Total	Electronic	Others	Total
Just-in-time (or pull-based) manufacturing	5	4	9	5	4	9
Elimination of waste in production	12	9	21	12	9	21
Cutting down costs	7	9	16	9	7	16
A set of principles used to manage production process	7	7	14	7	7	14
A set of principles that can be applied to supply chain management	3	6	9	6	3	9
Others	1	3	4	2	2	4
Total	35	38	73	41	32	73

Major Areas of Lean Thinking Application

To those manufacturers who have applied lean thinking, the major areas of application are production and quality control as shown in Table 3. The best results of application occur in process control, quality control, production scheduling, and customer management (Table 4). The high score for customer management suggests that application of lean thinking in SCM can bring about significant benefits (Czabke et al. 2008). To those who have not applied but are investigating the possibility, the potential areas of application are procurement, inventory management, production, and administration. The differences suggest that for the early adopters of lean thinking, application is mainly in the production areas. For the latecomers, there is a tendency to shift the focus to a wider spectrum of SCM. The finding again suggests an increasing recognition of the potential benefits of applying lean thinking across the whole supply chain.

Table 3 Major and potential areas of lean thinking application

Area of application	**Firms which have applied lean thinking**		**Firms which are considering applying lean thinking**	
	Count	Per cent	Count	Per cent
Procurement	7	14.0	5	22.7
Inventory management	7	14.0	5	22.7
Production	11	22.0	5	22.7

Layout design	5	10.0	0	0.0
Quality control	8	16.0	2	9.2
Maintenance	2	4.0	0	0.0
Administration	6	12.0	5	22.7
Finance	2	4.0	0	0.0
Others	2	4.0	0	0.0
Total	50	100.0	22	100.0

Note: Many respondents reported multiple areas of application

Table 4 Results of lean thinking application

Function / activity	Median	Mean	S.D.
Inventory management	3	3.3	1.0
Team approach	3	3.4*	0.8
Process control	3.5	3.6*	1.1
Maintenance	3	3.2	1.1
Layout / handling	3	3.3	0.6
Supplier management	3	3.0	0.9
Setups	3	3.1	0.9
Quality control	4	3.7***	0.6
Production scheduling	4	3.6**	0.7
Customer management	4	4.1***	0.7

Rating scale: (1) the worst → (5) the best
* Significant at α = 0.1; ** Significant at α = 0.05; *** Significant at α = 0.01

Benefits of Lean Thinking Application

Manufacturers who have applied lean thinking and those who have not but are considering applying were asked about their views on the benefits of lean thinking application. The findings are shown in Table 5. To the adopters, the major benefit reported is reduction of cost and waste in terms of inventories, labour, and cycle time. Other benefits include standardized process and improvements in demand management, information flow, and competitiveness. The findings are in alignment with the literature (Browning & Heath 2009; Sharma & LaPlaca 2005; Womack & Jones 2003). To the non-adopters, it seems that the expected benefits no longer limit to production cost reduction but extend to other aspects of SCM. The relatively even distribution of expected benefits across the list may also reflect the uncertainty of the manufacturers due to a lack of knowledge in where lean thinking should be applied.

Table 5 Reported and expected benefits of lean thinking application

Benefits of lean thinking application	Reported by firms which have applied lean thinking		Expected by firms which are considering applying lean thinking	
	Count	Per cent	Count	Per cent
Reduction of cost and waste	12	10.9	4	7.7
Reduction of inventories	8	7.3	4	7.7
Standardized process	8	7.3	4	7.7
Reduction of labour cost	8	7.3	3	5.8
More profit	7	6.4	3	5.8
Reduction of cycle time	8	7.3	3	5.8
Improved quality	5	4.5	3	5.8
Improved flexibility	7	6.4	4	7.7
Improved demand management	8	7.3	4	7.7
Higher customer service level	7	6.4	4	7.7
Material flow improvement	4	3.6	4	7.7
Information flow improvement	8	7.3	3	5.8
Improvement in relationship with suppliers	5	4.5	2	3.8
Improvement in relationship with customers	7	6.4	3	5.8
Improved competitiveness	8	7.3	4	7.7
Total	110	100.0	52	100.0

Note: Many respondents reported multiple benefits of lean thinking application

Difficulties Encountered in Lean Thinking Application

Again, manufacturers who have applied lean thinking and those who have not but are considering applying were asked about the difficulties they encountered or expected. Those who are not considering applying were also asked to state their reasons. The findings are shown in Table 6. Adopters and no-adopters alike consider communication between workers and managers as the major challenge in applying lean thinking suggesting that visibility is critical. To the adopters, collaboration with supply chain members is another major challenge that is also related to communication. The findings align with the literature (Cox & Chicksand 2005; Czabke et al. 2008). Therefore, it can be concluded that visibility, information sharing and communication is vital to the success of lean thinking application in SCM. To the non-adopters, the other major difficulty expected is recognition of waste. This finding reinforces the belief that many manufacturers may not know where lean thinking should be applied and are hence discouraged from taking the initiative.

For manufacturers who are not considering applying lean thinking, the major reason is that they do not know where to apply. This reveals a need for enhancement in the awareness and knowledge of lean thinking in the industries. The other common obstacle is that lean thinking does not form part of the company's integrated strategies (Johnson et al. 2007). This suggests that to promote lean thinking in SCM, top management support and perhaps a corresponding change in company strategy and culture may be necessary.

Table 6 Reported and expected difficulties in applying lean thinking

Challenges in applying lean thinking	**Reported by firms which have applied lean thinking**		**Expected by firms which are considering applying lean thinking**		**Reasons given by firms which are not considering applying lean thinking**	
	Count	Percent	Count	Percent	Count	Percent
Communication between workers & managers	8	18.2	4	26.7	2	11.1
Invisible management commitment	4	9.1	1	6.7	2	11.1
Recognition of waste	6	13.6	3	20.0	1	5.6
Short-term profit expectation	6	13.6	1	6.7	2	11.1
Cost of implementation	5	11.4	0	0.0	1	5.6
Non-integrated strategies	0	0.0	1	6.7	3	16.7
Responding to market uncertainties	2	4.5	1	6.7	1	5.6
Collaboration with supply chain members	8	18.2	2	13.3	0	0.0
Cultural change	5	11.4	1	6.7	2	11.1
Do not know where to employ	0	0.0	1	6.7	4	22.2
Total	44	100.0	15	100.0	18	100.0

Note: Many respondents reported multiple difficulties in applying lean thinking

CONCLUSIONS AND FURTHER RESEARCH

Through a questionnaire survey, this study has revealed the current status of lean thinking application in the manufacturing sector of China focusing on the SMMs. The findings may shed light on the situation in other developing countries such as India, Vietnam, and Mexico. The findings suggest that application of lean thinking by the SMMs in the manufacturing sector of China is not widespread. Only about half of the responded companies have applied lean thinking in different areas. To the surveyed manufacturers, lean thinking mainly refers to waste reduction in production hence cost cutting. To those who have applied lean thinking, the major areas of application are production and quality control. The best results of application occur in process control, quality control, production scheduling, and customer management. The major benefits obtained are reduction in cost and waste, inventory, labour, and cycle time, as well as standardized process, improved demand management, enhanced information flow, and increased competitiveness. The major difficulties encountered are communication between workers and managers, and collaboration with supply chain members. Chi-square test reveals that medium-sized manufacturers appear to have a stronger tendency to apply the concept than their smaller counterparts. The test also discloses that firms not applying lean thinking seem to have different perceived difficulties. To them, short-term profit expectation, non-integrated strategies, and not knowing where lean thinking can be applied are the major obstacles. However, chi-square tests reveal no association between industry type and tendency of application, firm size and area of application, or application status and perceived benefits.

This study is largely a status survey using relatively simple statistics to present a general picture of lean thinking application by the SMMs in China. Although it does have contributed to knowledge by providing a snapshot of the current situation, the relatively small sample size has prohibited the use of more sophisticated statistical tests on the data to reveal further information. It may impact on the robustness of the results, which therefore need to be generalized with caution. The complex nature of China's transitional economy and political considerations may also influence the perspectives and practices of small manufacturers in formulating their lean thinking application strategies thus limiting the generalizability of the findings. Future research may extend the survey to cover a larger sample and to include other business partners so as to investigate the feasibility and benefits of applying lean thinking across the whole supply chain. Exploratory studies on the critical success factors of lean thinking application can also be conducted using in-depth case study approach to further investigate the challenges faced by companies of different sizes and business types. This may help develop a framework or a set of guidelines that can assist the whole industry in applying the lean thinking principles to maximize the overall benefits.

ACKNOWLEDGEMENTS
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REFERENCES
Browning TR & Heath RD 2009, 'Reconceptualizing the effects of lean on production costs with evidence from the F-22 program', *Journal of Operations Management*, vol. 27, pp. 23-44.

Burgess K, Singh PJ & Koroglu R 2006, 'Supply chain management: a structured literature review and implications for future research', *International Journal of Operations & Production Management*, vol. 26, no. 7, pp. 703-29.

Chopra S & Meindl P 2010, *Supply Chain Management: Strategy, Planning, & Operations*, Global Edition, New York: Pearson Prentice-Hall.

Cox A & Chicksand D 2005, 'The limits of lean management thinking: multiple retailers and food and farming supply chains', *European Management Journal*, vol. 23, no. 6, pp. 648-62.

Czabke J, Hansen EN & Doolen TL 2008, 'A multisite field study of lean thinking in US and German secondary wood Products manufacturers', *Forest Products Journal*, vol. 58, no. 9, pp. 77-85.

Fearne A & Fowler N 2006, 'Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation', *Supply Chain Management: An International Journal*, vol. 11, no. 4, pp. 283-87.

Johnson DM, Sun JC & Johnson MA 2007, 'Integrating multiple manufacturing initiatives: challenge for automotive suppliers', *Measuring Business Excellence*, vol. 11, no. 3, pp. 41-56.

Kator C 2007, ‘Thriving on lean’, *Modern Materials Handling*, vol. 62, pp. 33-6. (1 February 2007)

Mehta VB & Shah HK 2005, ‘Characteristics of a work organization from a lean perspective’, *Engineering Management Journal*, vol. 17, no. 2, pp. 14-20.

National Bureau of Statistics of China 2005, *First China Economic Census (No. 2)*, viewed 20 December 2009, <http://www.stats.gov.cn/zgjjpc/cgfb/t20051214_402296016.htm> (in Chinese).

Parks CM 2002, ‘Instil lean thinking’, *Industrial Management*, vol. 44, pp. 14-18. (September/October)

Sharma A & LaPlaca P 2005, ‘Marketing in the emerging era of build-to-order manufacturing’, *Industrial Management*, vol. 34, no. 5, pp. 476-86.

Taj S 2008, ‘Lean manufacturing performance in China: assessment of 65 manufacturing plants’, *Journal of Manufacturing Technology Management*, vol. 19, no. 2, pp. 217-34.

Womack JP & Jones DT 2003, *Lean Thinking*, New York: Simon and Schuster.

Wood N 2004, ‘Lean thinking: what it is and what it isn’t’, *Management Services*, vol. 48, no. 2, pp. 8-11.

ORDER ARRIVAL TIME AND QUANTITY FORECASTING WITH ANFIS UNDER HYBRID MTS/MTO ENVIRONMENT

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ABSTRACT
We consider the situation where manufacturers implement forecasting to predict the plausible next order arrival time and quantity so that they can pre-produce to shorten order lead time without carrying excessive inventories. We adopt the adaptive neural-fuzzy inference systems (ANFIS) to infer the next order arrival time and order quantity after training previous order related information. To provide decision makers with tractable decision domains and inference rules, we further restrict the levels of fuzzy decision variables to have small amount of fuzzy inference rules.

We experimented with three kinds of market demand patterns and found that an ANFIS with 10 x 10 rules can have MAPE of 1% for order arrival time and quantity as well. By reducing the ANFIS to 3 x 5 rules, it still has MAPE of approximately 15%, and decision makers can learn the 3 x 5 rules easily to make reasonable good decisions without relying on the ANFIS.
KEYWORDS: make-to-order, make-to-stock, hybrid MTS/MTO, ANFIS, forecast

INTRODUCTION

Sharing information on market, production capacity and inventory statuses is well known to help supply chain members reduce the inventory costs and mitigate the bullwhip effects. However, in practice, many manufacturers still have difficulties in obtaining market and inventory information from their customers due to the reasons such as the lack of trust, not major account, high investment cost, etc.

When information sharing is not feasible, manufacturers can resort to forecasting to predict the plausible next order arrival time and quantity so that they can pre-produce to shorten order lead time without carrying excess inventory.

In make-to-order (MTO) strategy, manufacturers begin the production cycle after receiving confirmed customers' orders. It reduces inventory risks but induces long lead times for customers. In make-to-stock (MTS) strategy, manufacturers produce based on the forecast of the market. It enables the possibility of mass production and satisfies the immediate needs of customers, but, in the meantime, it incurs either excessive inventories or obsolescent products.

To meet with the requirements of mass customization as well as respond to the market promptly, manufacturers implement hybrid MTS/MTO strategy to achieve the goals (Ernst and Kamrad, 2000; Soman et al., 2004; Su, Chang and Ferguson, 2005). With hybrid MTS and MTO production systems, manufacturers benefit by implementing postponement to pre-purchase production parts and/or pre-produce possible orders with MTS strategy based on the forecasted order arrival time and quantity.

In hybrid MTS/MTO, there is a customer order decoupling point (CODP) that the processes before the CODP are produced based on MTS, while those after the CODP are MTO, Figure 1. CODP is a conceptual point in the production process, and the realization of it is through postponement, i.e., if the CODP can be defined as a postponement point for the product. Defining the appropriate CODP deployment along the production process is a challenging job, especially considering the changing characteristics of the market as well as the usually uncertain supply of parts (Van Donk, 2001； Kerkkanen, 2007).

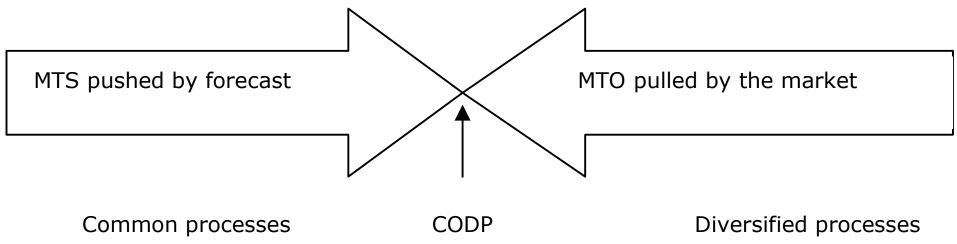

Figure 1 Customer order decoupling point in manufacturing processes

By knowing the order arrival time and quantity, manufacturers can set the appropriate CODP to pre-procure parts and pre-produce products to reduce the lead times for customers. In this study, we consider forecasting the next order arrival time and order quantity under the hybrid MTS and MTO production environment where the manufacturer has no information sharing with his customers.

A hybrid MTS/MTO system is executed in an MTO environment with an MTS strategy for semi-finished parts, or in other phrase, setting a postponed point for those parts. Thus, with accurate forecast of the next order arrival time and quantity, a hybrid MTS/MTO system can have benefits of customization and short lead times (Van Donk, 2001； Soman et al., 2004；Kerkkanen, 2007).

Most forecasting systems rely on complicated rules to enhance their accuracy; however, the rules are not simple enough for decision makers to convert them into human intelligence to make a reasonable good forecast. We adopt the adaptive neural-fuzzy inference systems (ANFIS) as the inference system to infer the next order arrival time and order quantity after training with data of previous order related information to obtain a fuzzy-inference-system (FIS). ANFIS has been widely used to predict system behaviors (e.g., Buyukbingol, et al., 2007).

As ANFIS can predict the next order arrival time and quantity, manufacturers are able to make purchase of parts or produce customers' orders in advance to reduce the lead times. To provide decision makers with tractable decision domains and inference rules, we further restrict the levels of fuzzy decision variables to have small amount of fuzzy inference rules. By learning the simple rules provided by the ANFIS, decision makers can still make proper purchase / production decisions by observing the statuses of the supply chain without having to perform the ANFIS, which is beneficial in their daily works.

EXPERIMENTS

The supply chain structure is adapted from an LCD manufacturer in Taiwan, Figure 2. Due to the volatile market demand, originally, the company implements an MTO strategy. However, MTO usually induces long lead time that the company plans to switch to mixed MTS/MTO. Successful implementation of the mixed strategy requires accurate forecast of required parts in terms of arrival time and required quantity. The supply chain is modeled with AutoMod simulation language. In this structure, retailers and wholesalers follow *s-S* inventory control policy while the manufacturer implements with a mixed MTS/MTO strategy.

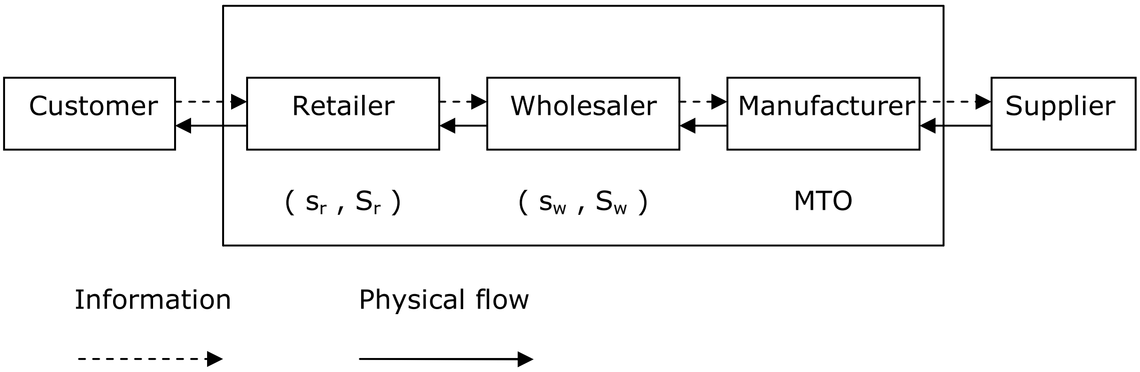

Figure 2: Supply chain structure

We experimented with customer demand curve as is shown in Figure 3. After simulating the supply chain, the order time and quantity of the manufacturer are depicted in Figure 4.

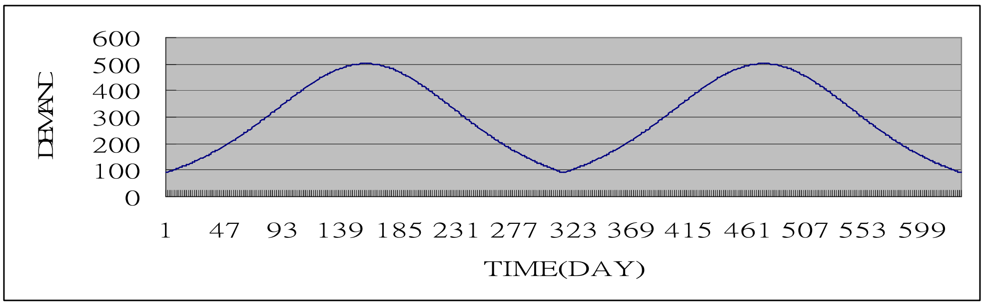

Figure 3 The Market demand pattern

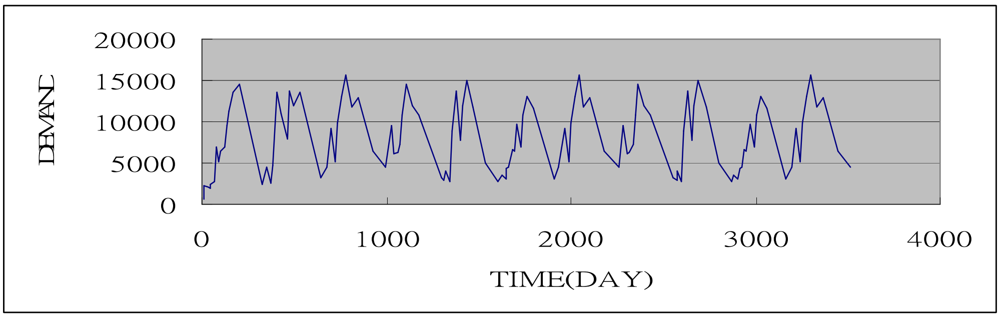

Figure 4 Order arrival time and quantity received by the manufacturer

We simulated the supply chain model to obtain the information regarding the time interval and quantity of the orders the manufacturer receives from the wholesaler. To smooth out the fluctuation, we adopted weighted moving average method to process the order arrival time interval and quantity, T_t and D_t, as the training data set for the ANFIS to predict T_{t+1} and D_{t+1}. T_t and D_t are modeled with linguistic variables having either three levels or five levels such as longer, long, medium, short and shorter time intervals for T_t. D_t has similar representation as well.

The ANFIS is constructed with the Fuzzy Toolbox of Matlab having Sugeno fuzzy inference system. It has two inputs, and one is the order arrival time interval and the other is the order quantity. The more number of levels we divide the input, the more accurate results we expect to have since multi-level enables ANFIS to portray more complex scenarios. The base model of the study is the situation when the manufacturer implements the MTO, and the compared model is the mixed MTS/MTO. The performance measure comprises the order waiting time multiplied by the order quantity of the wholesalers and the manufacturer's inventories.

From the results of the experiments, Table 1, we found that an ANFIS with 10 x 10 rules can have MAPE (mean absolute percentage error) of about 1% for order arrival time and quantity as well. By reducing the ANFIS to 3 x 5 rules, the ANFIS can still have MAPE of approximately 15%, which is accurate enough for decision makers to learn the 3 x 5 rules and make decisions without relying on the ANFIS to achieve a reasonable good forecasting result. The MAPE values of the experiments show good forecast capability of the ANFIS model (Chang et al., 2007).

Table 1: Experiment results

250 training cases / 58 testing cases	Experiments		
	Model-1	Model-2	Model-3
No. of rules	10×10	3×5	3×3
MAPE in time interval	1%	15.23%	26.3%
No. of rules	10×10	3×5	3×3
MAPE in demand quantity	1.12%	16.8%	23%
Total improvement rate	99%	26.7%	5%

CONCLUSIONS

Traditional supply chain members need to stock a lot of inventories to cope with the volatility of the market demand in order to maintain high service level of product availability and short lead times. With a hybrid MTS/MTO strategy, a manufacturer can set an appropriate CODP along their production processes with accurate forecasts of order arrival time and quantity to reduce inventories while maintaining high customer service level. This study implements ANFIS to predict the next order arrival time and quantity and has shown great improvement in performance measures when more rules (10 x 10) are implemented and reasonably good improvement when only 3 x 5 rules are used.

Despite fewer rules is not so accurate in forecasting, it provides decision makers with tractable rules to manage their daily forecast of the next order arrival time and quantity. Future research can extend our work with different kinds of market demand patterns as well as experimenting with other scenarios such as fixing CODP along the production processes, different composition of performance measures, etc.

REFERENCES

Buyukbingol, E., Sisman, A., Akyildiz, M., Alparslan, F.N. and Adejare, A. (2007). "Adaptive neuro-fuzzy inference system(ANFIS): A new approach to predictive in QSAR application: A study of neuro-fuzzy modeling of PCP-based NMDA receptor antagonists," *Bioorganic and Medicinal Chemistry* **15**: 4265-4282.

Chang, S.H., Pai, P.F., Yuan, K.J., Wang, B.C., and Li, R.K. (2003). "Heuristic PAC model for hybrid MTO and MTS production environment," *International Journal of Production Economics* **85**: 347-358.

Ernst, R. and Kamrad, B. (2000). "Evaluation of supply chain structures through modularization and postponement," *European Journal of Operational Research* **124**: 495-510.

Kerkkanen, A. (2007). "Determining semi-finished products to be stocked when changing the MTS-MTO policy: Case of a steel mill," *International Journal of Production Economics* **108**: 111-118.

Soman, C.A., Van Donk, D.P. and Gaalman, G. (2004). "Combined make-to-order and make-to-stock in a food production system," *International Journal of Production Economics* **90**: 233-235.

Su, J.C.P., Chang, Y.L. and Ferguson, M. (2005). "Evaluation of postponement structures to accommodate mass customization," *Journal of Operations Management* **23**: 305-318.

Van Donk, D.P. (2001). "Make to stock or make to order: The decoupling point in the food processing industries," *International Journal of Production Economics* **69**: 297-306.

UTILIZATION-BASED SIMULATION FOR ANTICIPATORY CHANGE PLANNING

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ABSTRACT

A demand-based operating of intralogistics-systems is hardly possible mostly due to dynamic markets and customer behaviour which lead to bad prediction of future states. One reason is the current structural change of logistics which is influenced by E-business whereby frequency of delivery dynamically increases and consignment sizes simultaneously decrease. This induces a varying extent of utilization of capacities of logistics systems, which are not configured appropriately for different situations and which can arise overloads or underloads.

In a dynamic environment of a demand-based intralogistics-system static calculation and dimension methods are not satisfactory. In fact, dynamic methods are necessary to handle the resulting dynamics and needed flexibility in intralogistics-systems. For this, the discrete event simulation is a promising tool.
This paper presents a simulation-based method, referred to as Anticipatory Change Planning (ACP), to deal properly with current and especially future dynamic system loads in intralogistics-systems.

INTRODUCTION

The ACP is an appropriate simulation-based concept, which ensures reliable, effective, and efficient operation of such intralogistics-systems in a constantly shifting and dynamic business environment [2]. The necessary capacity change will demand an early dynamic preview. The necessary changes on its part impose possible system adaptations which also have to be checked as to their potential of solving problems and suitability as well as to achieve an optimum implementation of the chosen solution.

Discrete-event simulation as the core of the concept is mostly applied for the designing and testing of different control configurations and as a tool for process optimization in logistics systems [1]. Apart from that, the scope of this kind of simulation has to be widened especially towards a continuous utilization-based view. Globalization and E-business are only some reasons for a demand of increasing performances of simulation tools, as the actual simulation tools are not able to handle the resulting dynamics and flexibility.

One important requirement of ACP is the system load, which consists of an "amount of work assignments of a system" [1]. Most of the simulation tools use this understanding of system load, but it is not sufficient for an ACP. Bernhard et al. define the system load as the flow of objects entering a system or as the number of objects entering a socio-technical system in a given time period [3, 4]. In case of the simulation of material flows, the moment an object enters the system is of special interest. The number of objects entering the system at a certain point in time and the time slot in-between are of further importance. Due to these facts, simulation tools have to change their database and function to fulfil the enormous requirements regarding dynamics and flexibility. The utilization-based simulation shows the first step to harmonize the requirements of logistics.

BASIC PRINCIPLES

Subsequently, the concepts of utilization-based simulation as well as the ACP are defined. Afterwards the method and the tool of the ACP are explained.

Definitions
A utilization-based simulation is a discrete-event simulation method which provides currently as well as in future expected degrees of capacity utilization and their resulting loads [cf.5]. This method is therefore applicable for the Anticipatory Change Planning with both the consideration of future capacity utilization and resulting loads. Within the scope of this contribution the degree of capacity utilization and the resulting loads are considered first, whereas in other research projects the physical stresses will be addressed, too.

The ACP is an appropriate simulation-based concept, which ensures reliable, effective, and efficient operation of logistical systems, factories, or networks in a constantly shifting and dynamic business environment [cf. 2, 6]. It comprises activities for the anticipatory identification of capacity changes in logistical systems or production systems as well as the proper choice and planning of adequate compensation measures in advance. The basic input value for the ACP is the anticipated system load. The utilization-based simulation for the ACP of intralogistics-systems is a model-based and aborning discharging of precise measures as a respond to the anticipated system load.

Material flow simulation as a tool for anticipatory change planning
Subsequent to the definitions a simulator has to be chosen which meets the specific requirements of the ACP.

For the realisation of a utilization-based simulation within the scope of the ACP relevant and commonly used methods in logistics have to be identified and analyzed. For this purpose criteria have to be defined, which must be fulfilled to a high degree by the methods [cf. 2]:

- Calculation and illustration of the progress of the material flow
- Illustration and assessment of parallelism and interactions of an intralogistics-system
- Calculation and illustration of statistical behaviour
- Generation and subsequent treatment of logistics key figures
- Integration of utilization-based availabilities of intralogistics-components
- Expandability of the model
- Consideration of influencing factors
- Multiple directions of processes
- Relation of cost and benefit.

The listed criteria represent the basis for an analysis of different methods for the ACP. Among those methods are general mathematical models (methods of operation research and forecasting) as well as computer-assisted simulation. According to the analysis of Kuhn et al. the discrete-event simulation of material flow has emerged as a basic methodology, especially thanks to the possibility to illustrate dynamic processes [cf. 2, 7, 8]. Predicting and analytical methods can also be considered to that extent that the future system load of an intralogistics-system can be predicted. Furthermore, an additional assessment or check of the results can be carried out with the help of analytical methods.

Based on the verification of the suitability of the discrete-event simulation of material flow, a corresponding computer-assisted material flow simulator has to be chosen in a next step. For this target, the VDI*-guideline 3633 [9] serves as a help. This guideline contains a criteria catalogue which supports the choice of an adequate simulator (according to the specific application). Within the scope of the ACP of intralogistics-systems the software Dosimis-3 of SDZ GmbH was chosen. In this simulation

* VDI (Verein Deutscher Ingenieure) = Association of German Engineers

environment some models were designed to verify and validate the approach of the Anticipatory Change Planning.
The material flow simulation is therefore the basis of the ACP. To guarantee an optimal application a procedure model has to be defined with which the ACP can be carried out successfully.

Approach for anticipatory change planning
The Anticipatory Change Planning is embedded in a structured procedure which consists of several phases (partially iterative). Figure 1 visualises the phases and their respective tools within the ACP.

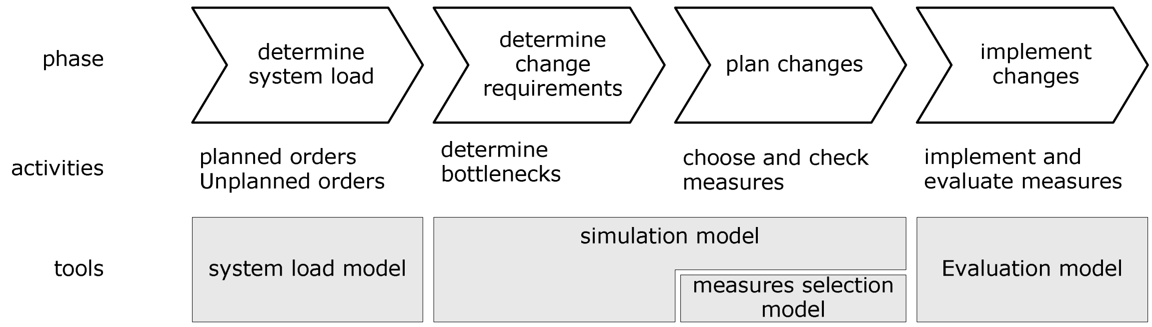

Figure 1: phases and tools for anticipatory change planning [10]

A utilization-based simulation represents the basis of the ACP. Based on a simulation model, the modification demands of an intralogistics-system can be determined with which the measures to compensate the existing bottlenecks can be selected and checked in the next step (ascertained by the measure selection model [cf. 6]). The procedure of a discrete-event simulation of an ACP is visualised in figure 2.

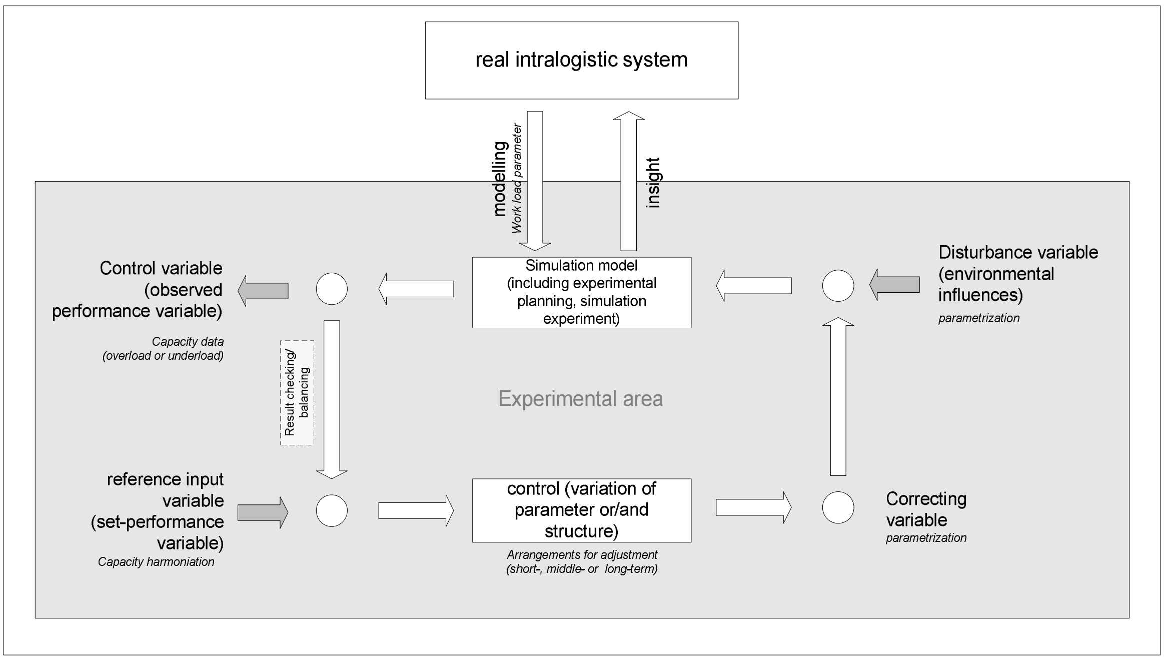

Figure 2: Function sketch for ACP in intralogistics-system according to [1, 11]
The basic considerations of a utilization-based simulation of the ACP are finally explained. In the following chapter a simulation model of a chosen intralogistics-system is described.

IMAGE OF A SIMULATION MODEL FOR AN ANTICIPATORY CHANGE PLANNING
An adequate tool for an ACP is a material flow simulation with which the procedure of Anticipatory Change Planning can be demonstrated on an existing intralogistics-system. A basis intralogistics-system is provided by the existing Logistics Condition Monitoring-Technology Laboratory (LogCoMo-Tech Lab) at the Technische Universität Dortmund. Due to the LogCoMo-Tec Lab, the ascertained results of ACP can be validated by a partial or complete transmission in the reality. This intralogistics-system consists of the following components:

- automated storage/retrieval system (MultiShuttle)
- continuous conveyor (roll conveyor) as well as
- distribution and consolidation elements

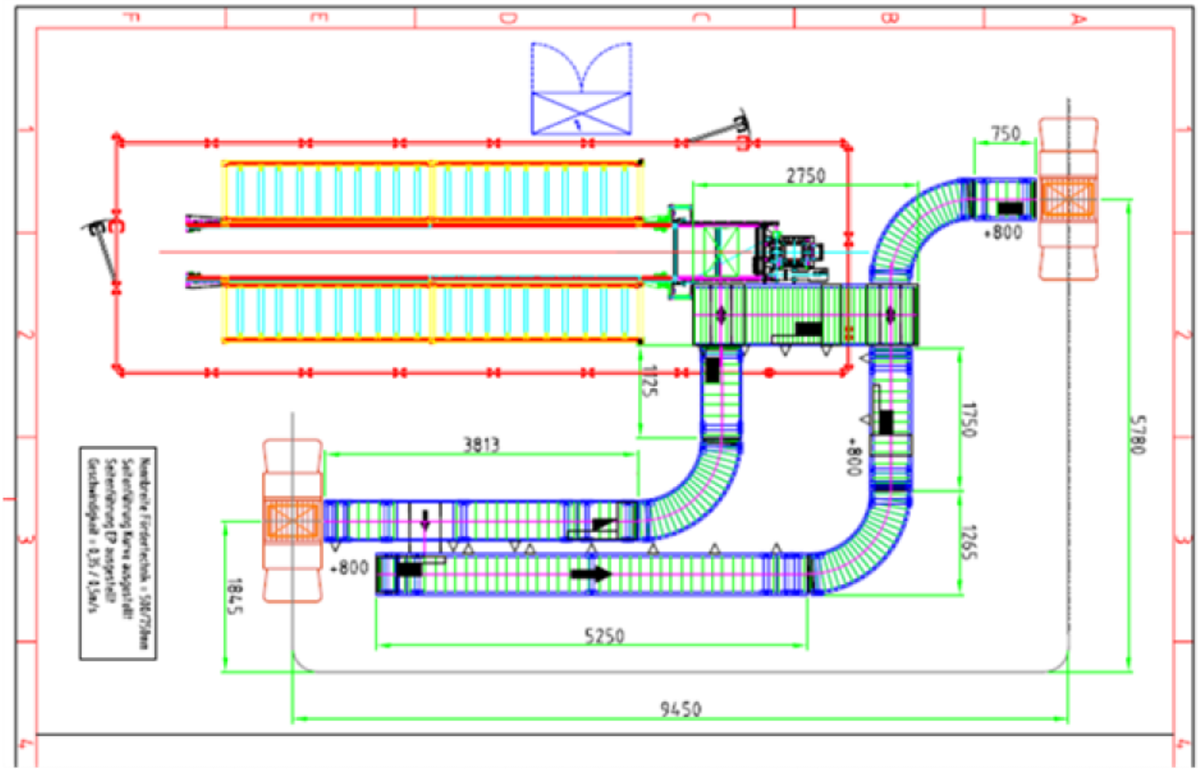

Figure 3: LogCoMo-Tech Lab as the basis for a ACP

The LogCoMo-Tech Lab is a concluded material flow, because of its demonstrating behaviour. Due to this fact, the existing intralogistics-system (cf. figure 3) has to be enlarged by, for example, a source, a sink, an order-picking station and a de-palletising station. This was necessary, because otherwise the research project regarding to the system load modification was not possible until now.

A simulation-based model for Anticipatory Change Planning
The basic system (cf. figure 3) has been enlarged. The enlargements are visualised as a simulation model in figure 4a. At the beginning of designing a model it is important to identify a basic system load scenario as well as the technical specification for dimensioning intralogistics-systems. In the following it is described an example of a simulation-based model for Anticipatory Change Planning.

Pallets with homogeneous and mixed (three different) goods enter on different times of the day into the goods receipt of the described intralogistics-system. The pallets with homogeneous goods are directly transported and stored into the pallet stock (stock with automated storage/retrieval system). If the goods are requested by an order, the pallets are directly transported to the goods issue.

The mixed pallets are transported from the good receipt to the de-palletise stations where the goods are sorted into bins (600x400x300 mm). Afterwards the goods are transported to a bin stock with two automated storage/retrieval systems. If these goods are requested by an order, the bins are taken out of the stock and transported to the order-picking stations. The goods are picked and palletised according to the orders, before the goods are transported in the goods issue. At several times of the day the goods (mixed and/or homogenous goods) are delivered in different loads.
After designing and parameterising the intralogistics-system modifications and their ascertained effects are to be considered. The Modifications of a system are done because of cost changes (productivity, inventory, capacity utilisation etc.), performance changes (service level, processing time etc.) or system load changes (new products, new production loads etc.) [cf. 5]. In the following a system load increase is exemplarily carried out by the simulation control circuit (cf. figure 2). It may help to understand a utilization-based simulation of an Anticipatory Change Planning.

At the beginning the existing computer-assisted simulation model of an intralogistics-system is determined with different parameters (here: reference variables) (e.g. de-palletise station: highest level of the processing time is around 85%). At this time it is possible for identifying the critical components of a system. If a change (system load change) exists or is predicted, the according parameters have to adapt in the existing simulation environment and simulation runs have to start again. After a simulation run it is possible to behold (by the animation of simulation software) and/or to calculate (by diagrams) the changes, whether the existing system can handle the change of the system load. An increasing of the system load in the exemplary intralogistics-system is represented by different bottlenecks presents (cf. figure 4a – red circle around the components).

In figure 5a the processing time of the de-palletise station (86.6%) is shown. In addition to the processing time, the running time as well as the waiting period for a delivery must be added to this time. Due to these added times, this de-palletise station can be considered as a critical component in time issues. However, to be able to operate the future bottlenecks, it is necessary to take one or a bundle of measures to arrange the set performance of an intralogistics-system. A possible measure for an intralogistsics-system mostly entails a modification in one or in several other intralogistics-components. In the example the following measures are chosen, which were selected with the help of the measure selection model [cf. 13]:

- increasing of conveyor speeds,
- application of an additional pallet truck (at the goods receipt) as well as
- the increase of the cycle time by "time-limited" adding an additional employee

These three described measures are to parameterise a new simulation model, which is shown in figure 4b.

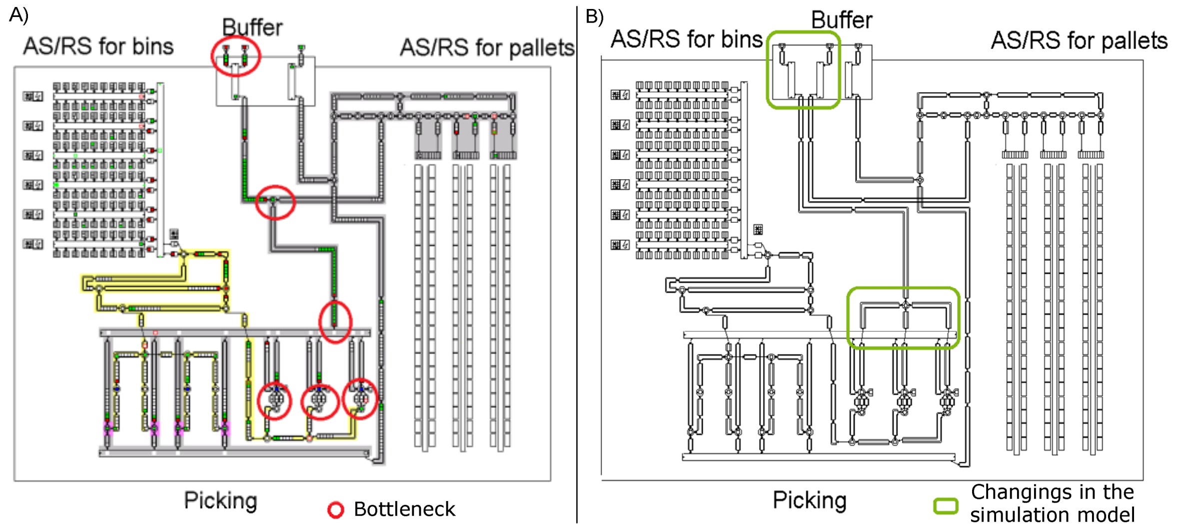

Figure 4: Simulation model (a: source model; b: adapted model)
After a simulation run with the simulation model (presented in figure 4b) the control variables and the reference variables are compared finally. This is also possible with different diagrams (one diagram is shown in figure 5b).

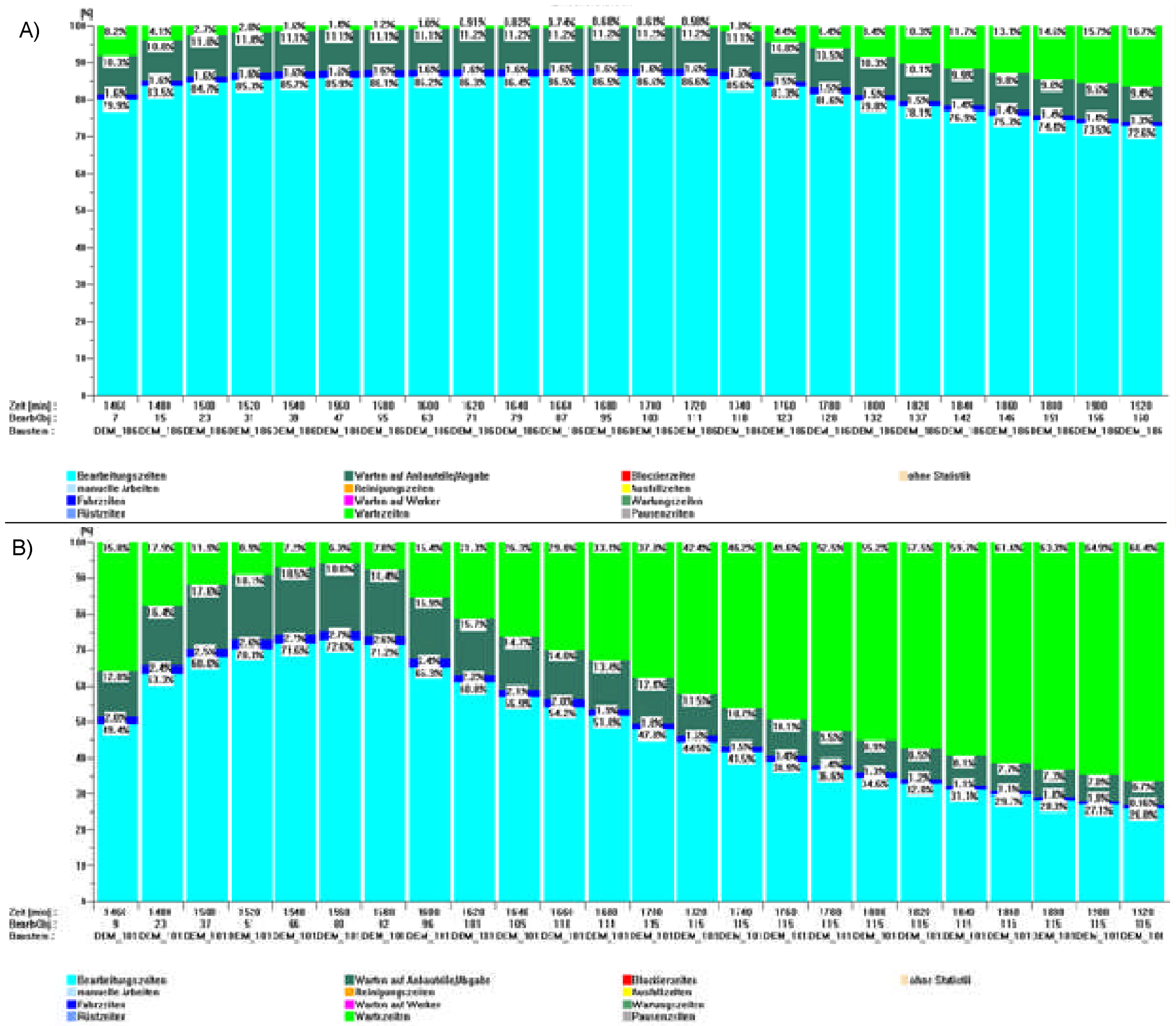

Figure 5: diagram of various times (a: increased system load in the source model; b: increased system load in an adapted simulation model)

It is evident that the level of the capacity utilization of the de-palletise station from approx. 100% to 80% has sunk. Due to this fact, the modified intralogistics-system can handle the future system load and the measures can be implemented in the reality.
The modified simulation model provides a “new” basis model with which new changes can be simulated again.

Integration in the IT scenery
To automate an Anticipatory Change Planning it is necessary to embed the existing information-technical scenery in a company. Therefore two different possibilities are existing: a database-oriented and a service-oriented architecture.

In a database-oriented architecture the relevant data from the according specific company IT-systems can be exported by the use of standard export features into a database [cf. figure 6]. As this figure shows the addition integrated scenarios help to consider highly “in-predictable” changes in other research activities for future projects.

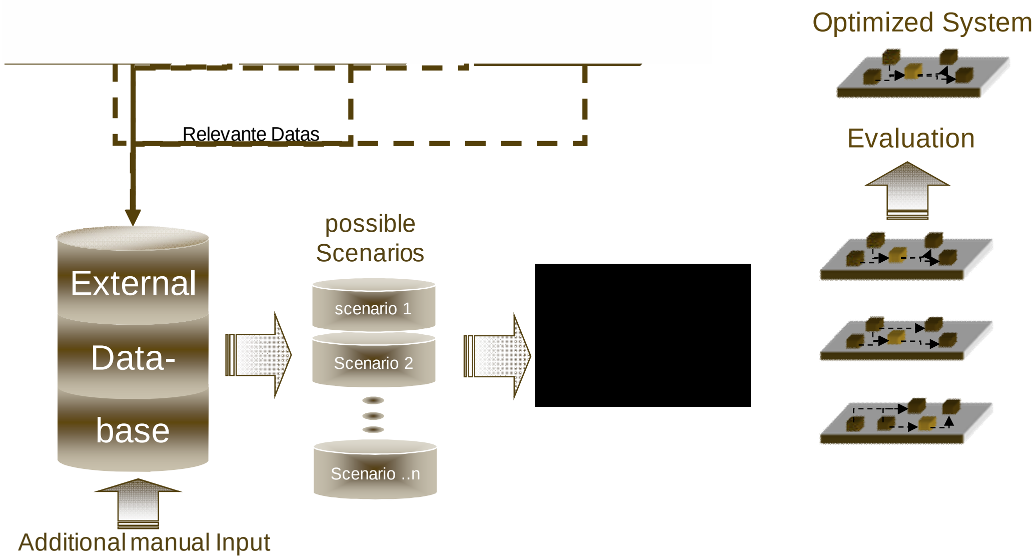

Figure 6: Database-orientated solution

In addition to the database-oriented architecture the integration into the IT scenery also can be done with a service-oriented architecture (SOA). The SOA is defined as a paradigm for the structuring and use of distributed functionality with different responsible [14]. On this occasion, particular modules or programs of different kinds are defined as a service. These services are adjunctive by each other by standardised interfaces with uniform data format. The services to integrate the ACP into the IT scenery is orientated by the phase model of the ACP (cf. figure 1). It is to develop a data service, scenario service, simulation service, measure service and evaluating service, which deliver date input defined above and standardised interfaces.

In the first step it is necessary to determine the necessary data basis for generating of particular models, different scenario analyses, different assessment and optimisation processes and system load fluctuations. The data input into the simulation model carries out by the standard export features from ERP-, PPS- and comparable systems and the MS Excel import function of Dosimis-3 of the relevant date sources. Due to this solution, a relatively arbitrary and undirected interface creation was substituted by a purposeful preventive selection of the relevant systems to be networked without slowing down the concept development until now.

CONCLUSION

It was shown in this paper that the material flow simulation is suited very well for the Anticipatory Change Planning. The model of the Anticipatory Change Planning distinguishes itself by a high degree in innovation. In this context particularly emphasised certain signs of the basic model are:

- Basic model is a holistic simulation approach concerning to the analysis of objects and the feature perimeter
- ACP approach can be considered as a preventive and proactive approach
- The concept of the Anticipatory Change Planning facilitates a continuous planning.

Nevertheless, it is to be marked that the first version of this model considers only the level of capacity utilisation. In following research projects the consideration of the load and the resulting stress is to be developed and integrate in order to realise the entire utilization-based simulation of the Anticipatory Change Planning. Analyses have shown that current simulation models and simulation tools primarily provide the dimensioning or the analysis of capacity feasibility of intralogistics-systems and the optimisation of the processes. A utilization-based consideration of the load and the resulting stress of components of an intralogistics-system can be examined with certain parameters in several simulation tools in principle, but this is not anticipated normally. Some of the simulation tools own integrated program interfaces with which such parameters can be installed. To realise a utilization-based consideration it is to be carried out preceding analyses concerning to the type and amount of the parameters, effects on other parameters and their evaluation possibilities.

In addition, it is obvious that the ACP approach works with "predictable" changes on the basis of predictable system load data until now. Researches and empiric findings have shown that highly "in-predictable" changes receive also an important position within the scope of the incentive of intralogistics-systems, but mostly not considered until now. On this occasion, certain changes cannot be designed because of absent technical and methodical support, as for example the level of the highly "in-predictable" changes as well as load-induced bottlenecks. Different publications within the scope of the collaborative research centres 696 show that intralogistics-systems or their components are normally oversized and have to be reduced to a life cycle-oriented level [cf. 15, 16]. Due to this reducing, the influence of the load and their effects (stress) cannot currently be considered in a utilization-based simulation of the Anticipatory Change Planning.

In the following period it is a matter of focussing on this highly "in-predictable" change. Also the transmission of these laboratory results to industrial intralogistics-systems is to be considered in other research projects to gain other realisations concerning the enlargement of the ACP model.

REFERENCES

[1] VDI-Guideline 3633 – Sheet 1 (2000) Simulation von Logistik-, Materialfluss und Produktionssystemen – Grundlagen. VDI-Verlag, Düsseldorf.

[2] Kuhn, A.; Bandow, G.; Wötzel, A.; Uygun, Y. (2009) Grundmethodik der Antizipativen Veränderungsplanung intralogistischer Systeme – Eine theoretische Analyse, In: ZWF – Zeitschrift für wirtschaftlichen Fabrikbetrieb. Hanser, München.

[3] Bernhard, J.; Sieke, H.; Schürmann, C. (2006) Standardisierte Systemlastbeschreibung für die Modellierung großer Netze in der Logistik. In: Wenzel, S. (ed) Simulation in Produktion und Logistik, ASIM Tagungsband, Erlangen.

[4] Wenzel, S.; Bernhard, J. (2008) Definition und Modellierung von Systemlasten für die Simulation logistischer Syteme. In: Nyhuis, P. (ed) Beiträge zu einer Theorie der Logistik. Springer, Berlin/Heidelberg.

[5] Kuhn, A.; Bandow, G.; Uygun, Y.; Wötzel, A. (2009) Nutzungsabhängige Simulation intralogistischer Systeme. In: Künne, B.; Tillmann, W.; Crostack, H.-A. (ed.): 3. Kolloquium des Sonderforschungsbereichs 696: Forderungsgerechte Auslegung von intralogistischen Systemen - Logistics on Demand. Verlag Praxiswissen, Dortmund.

[6] Uygun, Y.; Luft, N.; Wötzel, A.; Bandow, G.; Kuhn, A. (2009) Simulation-Based Improvement of Reliability of intralogistics-systems. In: Proceedings of the 14th International Symposium on Logistics: Global Supply Chains and Inter-Firm Networks. Istanbul/Türkei 5.-8. Juli 2009. S. 267-278.

[7] Bandow, G.; Wötzel, A. (2010) Modellierungsansätze zur antizipativen Veränderungsplanung in intralogistischen Systemen. In: Bandow, G.; Holzmüller, H. H. (ed.): Das ist gar kein Modell - Unterschiedliche Modelle und Modellierungen in Betriebswirtschaftslehre und Ingenieurwissenschaften. Gabler, Wiesbaden.

[8] Jungmann, T.; Kuhn, A.; Bandow, G.: Antizipative Veränderungsplanung - eine Simulationsaufgabe? In: Crostack, H.-A.; ten Hompel, M. (ed.): 1. Kolloquium des Sonderforschungsbereichs 696: Forderungsgerechte Auslegung von intralogistischen Systemen - Logistics on Demand. Verlag Praxiswissen, Dortmund.

[9] VDI-guideline 3633 - sheet 4 (1997) Auswahl von Simulationswerkzeugen - Leistungsumfang und Unterscheidungsmerkmale. VDI-Verlag, Düsseldorf.

[10] Uygun, Y.; Wötzel, A. (2009) Antizipative Veränderungsplanung intralogistischer Systeme - Eigenschaften und Handlungsfelder. In: Zeitschrift für wirtschaftlichen Fabrikbetrieb, Hanser, München.

[11] Kühn, W. (2006) Digitale Fabrik – Fabriksimulation für Produktionsplaner. Hanser, München et al.

[12] Schroer, W. (2005) MultiShuttle – universell einsetzbar. In: Hebezeuge und Fördermittel. Huss, Berlin.

[13] Uygun, Y.; Luft, N. (2010) Vorgehensmodell zur Maßnahmenselektion: Das Maßnahmenfilter-Modell. In: Bandow, G.; Holzmüller, H. H. (ed.) Das ist gar kein

Modell - Unterschiedliche Modelle und Modellierungen in Betriebswirtschaftslehre und Ingenieurwissenschaften. Gabler, Wiesbaden.

[14] OASIS (2006): Reference Model for Service Oriented Architecture 1.0; OASIS Standard. URL: http://docs.oasis-open.org/soa-rm/v1.0/.

[15] Wenzel, S.; Köpcke, C.; Bandow, G. (2010) Reliability of Intralogistics-Systems - Oversizing or Maintenance. In: Proceedings of the 4th CIRP International Conference on Competitive Manufacturing, 03.-05.02.2010, Stellenbosch, South Africa, S. 383-388.

[16] Wenzel, S.; Bandow, G. (2009) Oversizing Or Maintenance - Two Ways For Reliable Intralogistics-Systems. In: Proceedings of 14th Annual International Conference on Industrial Engineering - Theory, Applications & Practice, 18.-21.10.2009, Anaheim, USA, S. 142-146.

SALES AND INVENTORY MANAGEMENT SYSTEM FOR FARMER'S STORE AND PRICE ELASTICITY OF DEMAND BASED ON STAYING TIME

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ABSTRACT

Farmer's store in which fresh agricultural product, e.g. green vegetables and fruits, are directly traded between farmers and consumers, obtains much attention in Japan because the products are characterized with their reasonable price and food security. Freshness of the product is also an important characteristic of the store. A farmer has to decide price and quantity of the products ships to the store. Stock shortage, i.e. opportunity loss, and excess of supply could be occurred according to the decision. However, each farmer does not have enough information, experience and knowledge to do this because their core competence is farming. We have already developed an information system to support this in famer's store. As an extension, we present a new measurement for price elasticity of demand based on staying time at the store. The measurement supports to determine suitable price of product combining with the information system. We show two examples of the measurement from actual farmer's store records and practical problems to utilize the proposed system.

Key Words: Inventory Control, Decision Support System, Consumer Behaviour

INTRODUCTION

As fresh agricultural products, i.e. fruits and vegetables, originate in nature, each of them has unique characteristics, e.g. size, weight, colour, taste, state of surface, production area, etc. There are no two products which have the same characteristics. This property is important difference between fresh agricultural products and industrial products which are repeatedly manufactured according to certain specification and plan. Therefore, their value and price also differ each as if the species and weight are identical. In fact, consumers select suitable fruits or vegetables for their own purpose, i.e. way of taste or styles of cooking. The property is also applied whether if it is packaged or boxed.

In general, Price Elasticity of Demand is obtained from quantity of demand at every price. However, it is impossible to define the elasticity for fresh agricultural product because of the property. Furthermore, the property may be presented in the case of industrial product. For example, well mass customized product has own custom part and the combination is often unique. A product using returned parts collected in reverse and green logistics system may differ in some conditions of durability or performance.

We have proposed and implemented a sales and inventory management information system for fresh agricultural product at Farmer's Store (Hanzawa et al). The system is characterized with which an e-mail is send to the farmer, to his cellar phone, to inform current sales tendency to replenish his stock. Horikawa et al. (2009) regard this replenishment mechanism as Vender Management Inventory and shows analyses. Kasai et al. (2009) updates database to identify 900 individual items and records detailed information of sales and arrivals. With the database, we can calculate mean staying time of the products of which species, price and farmer is the same from the difference between arrival time and departure time. Ma et al. (2009) analyzes sales records of the system and applies forecasting methodologies, e.g. Box Jenkins methods and etc., to the store.

Aim of this paper is to propose a new definition of Price Elasticity of Demand based on staying time at the store. From one year operation records of the famer's store, we show some examples of the price elasticity. We present consumer's purchasing behaviour at the store and price zone which consumers attracted from analysis based on the price elasticity.

Farmer's store and its business are introduced at Section 2. We present the proposed information system at Section 3. Price elasticity and case study is shown in Section 4 and 5 respectively. Finally we conclude at Section 6.

FARMER'S STORE

Farmer's store becomes an important distribution channel for fresh agriculture product in Japan for the last 20 years. Farmers directly sell their products to consumers at the store. Because farmer who made the product is obvious, the products satisfy consumer's demand on food security. The store called *Sanchoku* which means direct sales at production area in Japan. The store is often referred as *farmer's market* in some literature. We use term farmer's store because of existence of two stages managements and decisions: farmer level and store level. With this characteristic, the store must be distinguished from general farmer's market we can see in other countries.

The farmer's store consists of customers, farmers, a manager who is a representative of farmers and a shop. Inside the shop, there are shelves and each shelf is assigned to a farmer. The farmer prepares and manages his products on the shelf for sale. Customers walk around inside of the shop and take some favourite products from these shelves. They make payment at cashier like supermarket while the farmer is able to work and spend his time in his farming field. Occasionally, he visits the store to confirm the inventory. If stock level gets below then he replenishes the products. After closing the store, the manager calculates total sales of the day and informs each farmer of the total sales.

Stores are usually managed by an independent farmer, farmer's cooperated union, municipal government and etc. We focused on farmer's cooperated union type because the others generally employ specialists for store management. On the other hands, at the farmer's cooperated union type, each farmer has to make decision on their production, shipment, sales and etc. However, core competence of farmers is agricultural production especially for the middle and small sized farmers. Therefore, they have no enough knowledge and method to manage their business in farmer's store. Certain support on their store business is necessary to manage and run the store. Utilization of an information system can be a smart solution.

At the same time, the store also receives in store level competition with another farmer's stores, supermarkets or conventional retail shops. One of difficulties in managing the store is satisfying both two level managements: farmer level and store level. Furthermore, member farmers can be regarded as a rival at the farmer level management. However, they have to cooperate in the store level management.

Akasawa Farmer's Store: Place of Case Study

As a case study, our theory and information system are evaluated at an actually existing farmer's store. The store located at suburb of Morioka city and it takes 30 minutes car drive from the city centre to the store. The store is established and managed by farmer's cooperative union and the chair of the union becomes a leader in management. Number of registered farmers are 134, i.e. 134 families. Annual sale of the store reaches about 200M yen, where management scale of the store is located at middle sized. Most of famers run small business and executed by retired people. They ships their products both regular distribution channel through Japan Agricultural Cooperatives, JA, and the store. The store staffs are chosen from housewives of farmers as a part-time worker. Most of them are working at cashier.

Figure 1 shows percentages of items in the 2007 annual sale. Main products are green vegetables, apples and grapes, where apples and grapes occupy over the half of the sale. Figure 2 shows percentages of each month in the annual sale. Over the 70% of the sale is obtained from September to December, i.e. high season of grapes and apples. At the store, problems of stock shortage and excess in supply become more severe than other farmer's stores. Solutions for this are expected.

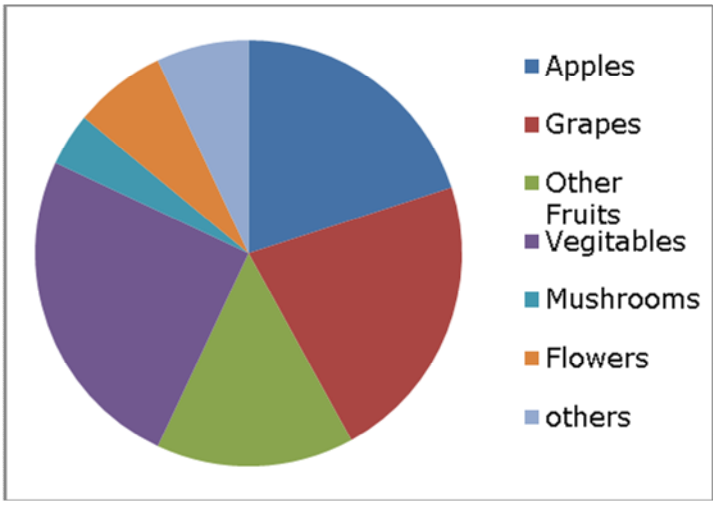

Figure 1: Main sales items and annual amount (2007)

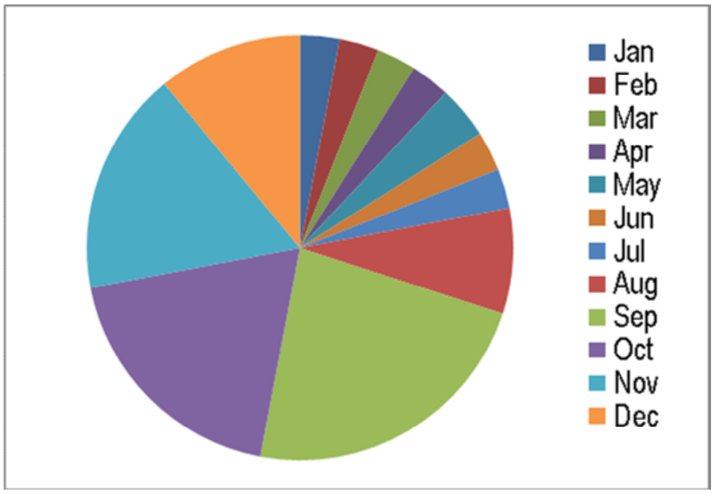

Figure 2: Monthly sales fluctuation (2007)

SALES AND INVENTORY MANAGEMENT SYSTEM

We have developed and implemented an information system for sales and inventory management at the farmer's store (Hanzawa et al. 2007, Kasai et al. 2009, etc.). The system is designed to realize and support farmer's business, e.g. sending email occasionally to let the farmers know current sales tendency and releasing current inventory level to consumer through web pages. The system consists of following functions: Product Arrival, Sales and Stocks, Promotion, Production Planning and Management Analysis.

- Product Arrival Management

Before displaying agricultural product at the store, a price tag is issued for each package of product. Item's name, price, name of the farmer, issued dates, contact address, bar-codes for cashier and, etc. are described on the tag. This information is entered to the terminals of information system at the office room and is sent to the Sales Management functions at the same time of printing. Kasai et al. (2009) extends the system to identify over 900 items where the former system identifies 15 categories of items.

- Sales and Stocks Management

Sales records are retrieved from POS terminals at cashier on every 15 minutes. The records are saved at Database and collated with arrival information collected from Product Arrival Management to update inventory information. Products of which quality is getting worse are drawn from the shelf. Stock information is updated when such adjustment occurs.

- Promotion Management

Introduction of the store, each farmer, products of the season are informed through web pages promotion. This function manages the pages and sends e-mails for every farmer to know his current sales tendency at previously determined time. The time can be set for every 15 minutes at most. However, the system sends the mail four times a day because of their request. Inventory information is retrieved from Sales Management.

For consumers support, according to the inventory information, currently selling products can be confirmed at the web pages with the maximum and the minimum prices. Because the store is generally located in farming area, consumers bear risk of stock shortage. With the pages, consumers can be well informed of current amount of stocks before departure. The information is also utilized to decide farmer's sales strategy.

- Production Planning (prototype)

As production area is limited to vicinity of the store, variety of products and season of harvest are limited to small and short. Therefore, variety of breed and high season of it are rather converged. With this situation, consumer may encounter stock shortage and farmers gain less profit because of lower price through stiff competition. This is a fundamental and structure problem of farmer's store. To overcome it, we are going to implement new function of sharing shipping plan among farmers and sales forecasting. Farmers will adjust shipping plan considering the sales forecasting and another farmers plan if it is possible.

- Management Analysis (prototype)

Management information is analyzed in this function. Major role of this function is demand forecasting and consumer's behaviour analysis. See Ma et al. (2009) for details.

Figure 3: Data Flow Diagram of proposed information system

	OS	DB	Programming Language
Arrival Management Server	Windows Server 2008	MS-SQL	Visual Basic 2008
Arrival Management Terminals	Windows XP	N/A	Visual Basic 2008
POS Terminals		TERAOKA Web Rise Series	
Sales & Inventory Management Server	Windows XP	MS-SQL	Visual Basic 2008
Sales Promotion Server	Linux	MySQL	JSP, Servlet

Table 1: Environment Setup of Developed System

Figure 3 shows a Data Flow Diagram of the proposed information system. POS terminals are introduced at cashier. Board members manage store strategy and operation. Table 1 shows an environmental set up of the information system. The system consists of 4 x86 servers, 4 PCs and 3 POS terminals, which these machines comprise a LAN with ether network. 3 PCs are used for Product Arrival Management System and the other is for Sales and Stocks Management. POS terminals have been introduced before the system implementation. Production Planning and Management Analysis are under development. A server for Sales Promotion Management is set at the university and connected the system through public circuit.

PRICE ELASTICITY OF DEMAND BASED ON STAYING TIME

Freshness of product is strong advantage point of farmer’s market. Some products are harvested a couple of hours before displaying in the store. To utilize the advantage, it will be important to manage staying time as an inventory control.

Generally, price of fresh agricultural product is determined at wholesale market established by national or local government in Japan. Therefore, farmers in Japan have less opportunity to commit decisions about price. The suitable price is determined according to price elasticity to balance supplies and demands (Soper 2004). However, every fresh agricultural product differs from others as their size and weight are determined by nature. Namely, it is difficult to compare effect in prices of two products because they are not identical. Therefore, price elasticity cannot be applied to the product without arrangements because the elasticity is calculated with number of the sold product. In this paper, we propose alternative measurement of price elasticity of demand. We define price elasticity of demand based on staying time as follows:

$$E_{x,y} = \frac{\text{propotionate change in staying time}}{\text{propotionate change in price}} = \frac{\left(T_y - T_x\right)\bar{T}}{\left(P_y - P_x\right)\bar{P}}$$

Here P and T represent price and staying time of the product. $\bar{T}$ and $\bar{P}$ represent mean of them. X and y represent each product.

We can calculate staying time at the store from point of arrival time to point of sales at cashier. In application of price elasticity in farmer's store, lead time for supply, i.e. agricultural production, takes relatively long time than consumption. Therefore, it is difficult to adjust current supply according to the price elasticity of supply.

Figure 4 shows concept of price elasticity of demand based on staying time. Horizontal and vertical axes show sold price and staying time at the store respectively. Demand curve shows relation between price and staying time of consumer. If the price increases, the staying time becomes longer because consumer feels that the price is relatively high. On the other hand, if the price decreases, the staying time becomes shorter. Supply curve shows decision of farmers. However, it is difficult to adjust amount of supply in short term, the curve is regarded as rather rigid line. The point crosses demand curve and supply curve is an ideal price point.

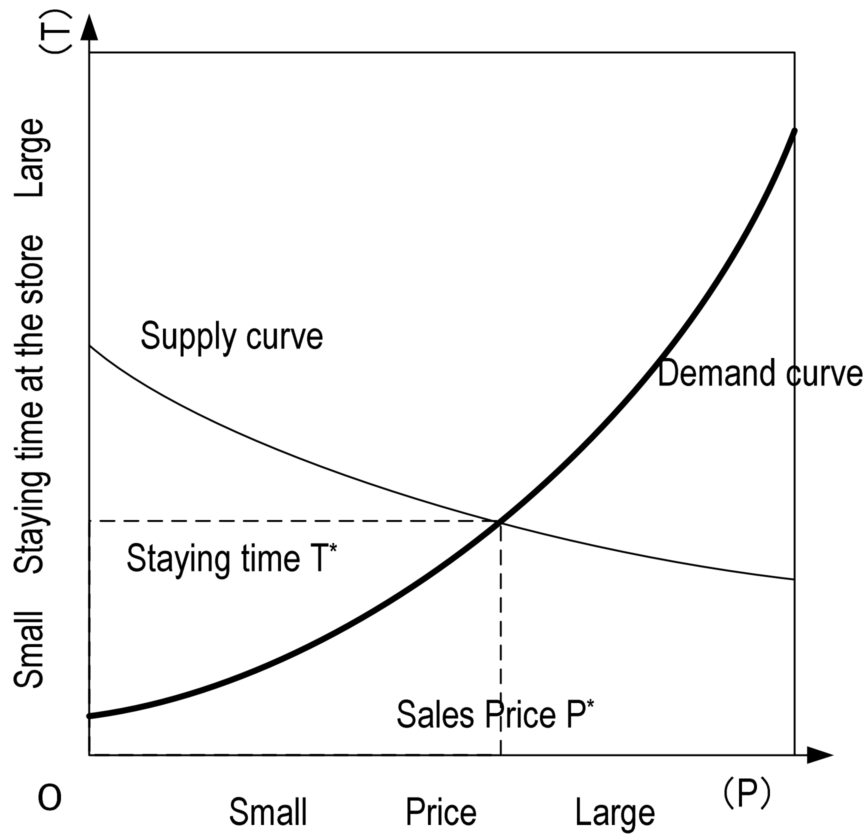

Figure 4: Price elasticity of demand based on Staying time

CASE STUDY

We have introduced a proposed information system to the store. Figure 5 shows relationship between price of a package of prune and mean staying time from September 2008 to August 2009. Here mean staying time is a mean of staying time of which price and unit, i.e. package or weight, are identical. Note that the points on the figure are not point elasticity of demands, but it shows relation between price and staying time. According to the figure, farmer can determine the price of their product at the suitable staying time. If he sets higher price, then stock level will be kept in higher level. On the other hand, he can reduce number of stocks in short time if he set the price lower. For fresh agricultural product, display time is rather limited and fixed time depending on each product to maintain its quality. Farmer decides his price in consideration of above conditions.

Figure 6 shows an example of packaged tomato. The figure does not show the same tendency with figure 5. In this example, there are some varieties in package sizes. Therefore, we cannot figure the relationship like figure 6. For the case, we have to unify the size of package or identify each size of package for decision for the packaged tomato.

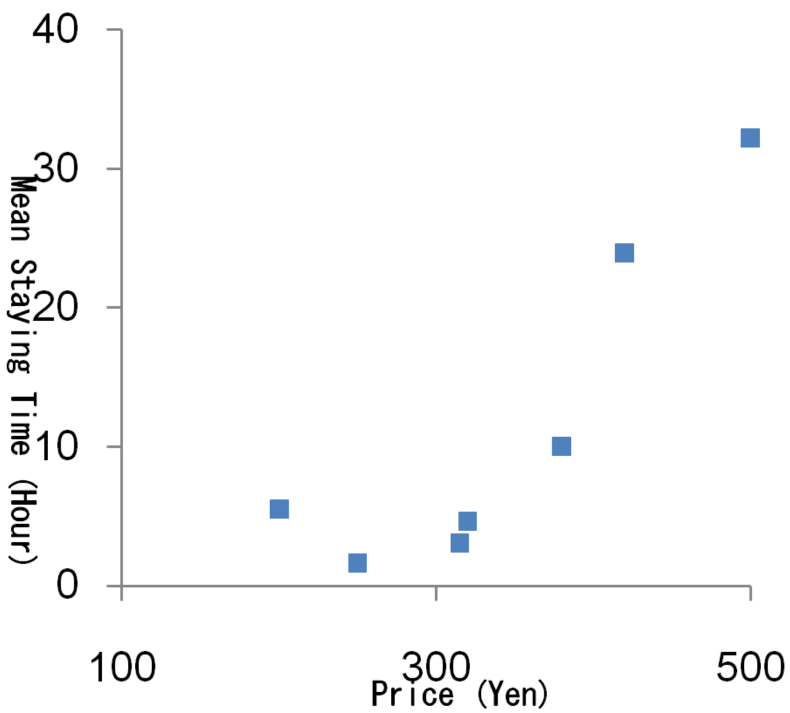

Figure 5: Mean staying time and price of a package of prune

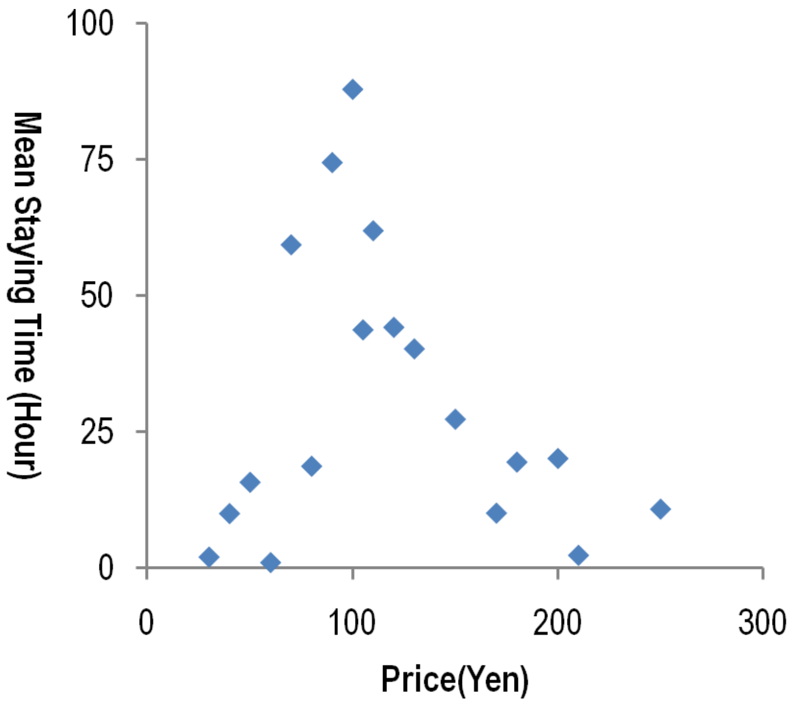

Figure 6: Mean staying time and price of a package of tomato.

CONCLUSION

In this paper, we present the role of farmer's store and an information system which supports business of the store. The store is characterized as two stage management and decision making. To overcome the problems in the store, the proposed information system provides special functions such as sending e-mail to farmers. Price elasticity of demand is extended to calculate by staying time, which staying time is more essential to represent sales tendency of fresh agricultural product than amount of sales. We show presented information system can be a method to observe the elasticity based on staying time. As a case study, we show two examples of relationship between prices and mean staying time. The examples show fundamental potential of the elasticity and some practical problems to utilize them.

Developing a decision support system to determine suitable price of agricultural products for farmers is next step of our research project. Furthermore, analysis on sales data, especially on different items, and development of Human Interface including concentration of information variety are planned. Presenting application of the new elasticity in another segment will be also an important issue.

REFERENCE

Hanzawa Y, Takeno T, Horikawa M, Sugawara M (2007) "Management Support System Realizing Direct Sales of Agricultural Product," *Proceedings of the 12th International Symposium on Logistics*, pp.396-401.

Horikawa, M., Takeno, T., Ohba, M., Sugawara, M. (2009) Vender Managed Inventory for Farmer's Markets, Proceedings of 20th International Conference on Production Research p. 153.

Kasai S, Takeno T, Horikawa M, Sugawara M (2009) "Development of Inventory Management System and Analysis of Consumer's Behavior in Farmer's Store," *Proceedings of the 10th Asia Pacific Industrial Engineering and Management System Conference*, CD-ROM.

Ma, X., Uetake, T., Horikawa, T., Takeno, T., Sugawara, M. (2009) Development of Sales Forecasting Model for Farmer's Market, *Proceedings of the 5th International Congress on Logistics and SCM Systems,* pp. 292-297.

Soper J (2004) "Mathematics for Economics and Business," 2nd eds, Blackwell Publishing, Malden, MA, pp. 213-220, USA.

ORDERING STRATEGIES FOR SHORT PRODUCT LIFECYCLE PRODUCTS

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ABSTRACT
For short lifecycle Made-To-Stock (MTS) products, owing to (i) short lifespan (quick obsolescence), (ii) difficulties in repeated negotiations and procurement, (iii) long procurement lead-time and (iv) lower unit cost of acquisition in committing to a larger trade volume, retailers prefer to commit to their supplier the entire product demand that they expect during the product lifecycle at the time of launching itself. However, it is also observed in many such products that the accuracy of lifecycle demand forecast improves with sales. This becomes a strong reason for retailers to not commit the entire expected demand at the launch itself. Patil, Avittathur and Shah (2008, 2010) have modelled this ordering strategies problem for an environment where product lifecycle demand is deterministic once the initial demand is known (in the early stage of the product lifecycle). They consider price markdown as a strategy only in the final stage of the product lifecycle. In this paper we attempt to model the ordering strategies problem for a more complex supply chain situation - where (i) product demand would continue to be uncertain throughout the product lifecycle, but with decreasing uncertainty as time passes and (ii) price markdown could be a revenue enhancing strategy from the intermediate stages of the product lifecycle itself - with the objective of maximizing the retailer's expected product life cycle profit keeping the material order before launch of product, subsequent lifecycle replenishment orders, order splitting while dispatching material (transport batch sizes) and price markdown as decision variables. Our experiments suggest the importance of markdowns, splitting of the initial order, and not committing the entire product demand in one go as significant contributors to the maximisation of retailer profit.

INTRODUCTION

For short lifecycle Made-To-Stock (MTS) products, owing to (i) short lifespan (quick obsolescence), (ii) difficulties in repeated negotiations and procurement, (iii) long procurement lead-time and (iv) lower unit cost of acquisition in committing to a larger trade volume, retailers prefer to commit to their supplier the entire product demand that they expect during the product lifecycle at the time of launching itself. However, it is also observed in many such products that if the product lifecycle were split into multiple phases, the variability of potential demand as a proportion of mean demand is very high before launch and in the early phases of the lifecycle which reduces drastically as the product matures (see diagram below). This is because of increase in information available about the product consumption with time that enables better forecasting and the strong relation of demand in a particular phase with the demand in the previous phase.

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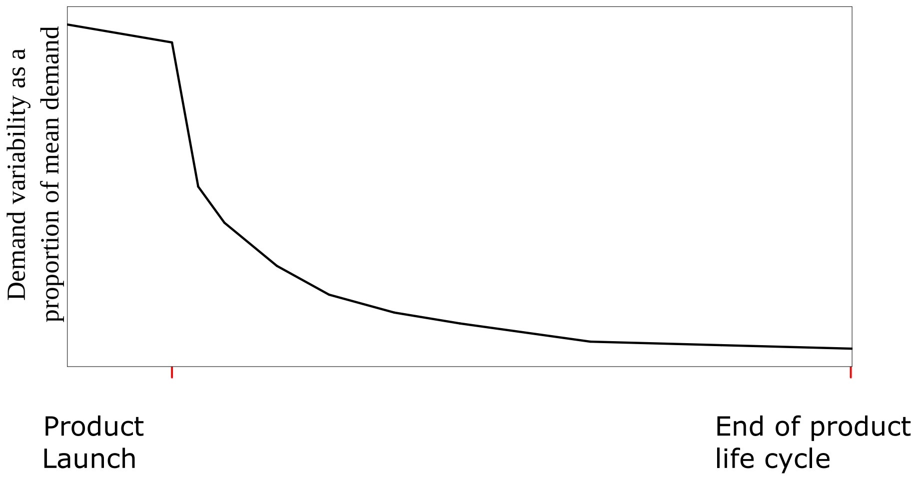

This implies that for such products the accuracy of demand forecasting improves substantially after the initial phases of the product lifecycle (Raman, 1999). The difficulty with demand prediction of Apple's iPads, which was launched in April 2010, is a case in point. According to an eCom Online Marketing blog (eCom Online Marketing, 2010), "while analysts are shying away from predicting initial iPad demand, they are taking a stab at sales for the full year. Even those vary widely." For the year 2010, the forecasts by different analysts vary from 2 million to 6 million in 2010.

We use a simple product lifecycle with two time periods to numerically illustrate the above pheno-menon. The starting points of the time periods correspond to the product launch and middle of the product lifecycle, respectively. Let the demand in the two time periods be as indicated in Table 1.

Table 1: Two period variable demand illustration

First Period Demand			Second Period Demand		
Scenario	Probability	Demand	Scenario	Probability	Demand
Low	0.25	100	Low Medium High	0.28 0.32 0.40	120 140 170
Medium	0.50	170	Low Medium High	0.30 0.40 0.30	200 230 270
High	0.25	250	Low Medium High	0.40 0.32 0.28	310 350 400

Table 2: Period 2 demand probabilities when forecast is made before and during Period 1

First Period Demand (FPD)		Second Period Demand (SPD)			SPD probability for forecast made			
						during First Period*		
						First Period Scenario		
Scenario	Proba-bility	Scenario	Proba-bility	Demand	before First Period	Low	Medium	High
Low FPD = 100	0.25	Low	0.28	120	0.07	0.28		
		Medium	0.32	140	0.08	0.32		
		High	0.40	170	0.10	0.40		
Medium FPD = 170	0.50	Low	0.30	200	0.15		0.30	
		Medium	0.40	230	0.20		0.40	
		High	0.30	270	0.15		0.30	
High	0.25	Low	0.40	310	0.10			0.40

FPD = 250		Medium	0.32	350	0.08			0.32
		High	0.28	400	0.07			0.28
Expected demand in period 2					240.1	146.4	233.0	348.0
Standard deviation of demand in period 2					77.1	20.8	27.2	36.6
Standard deviation / Expected demand					32%	14%	12%	11%

* Raman (1999) and Fisher and Raman (1996) indicate that demand in a period can be forecast accurately once some part of the demand in that period is known.

As can be seen from Table 1, there are three demand scenarios in the first period. In second period, there are three demand scenarios for each of the first period scenario. Thus demand in second period is a function of demand in first period. Then, as can be seen in Table 2, the probability of demand in second period when there is no information about first period demand (before product launch) is significantly different from when there is sufficient information of first period demand (i.e., during first period). It can be seen that the demand standard deviation as a proportion of expected demand is at most 14% when forecast is made during first period, while it is 32% when the forecast is made before first period. The considerable improvement in demand forecasting as the product lifecycle matures becomes a strong reason for retailers to not commit the entire expected lifecycle demand at the launch itself. A single order would be beneficial from the view-point of saving on fixed costs in ordering and transportation, while multiple orders would be beneficial from the view-point of (i) quicker and more accurate response, and (ii) lower inventory costs.

LITERATURE REVIEW

Patil *et. al.* (2008, 2010) provides reference to related literature that brings out the research significance of the class of problems to which the problem in this paper belongs to. For reader convenience, we reproduce below the relevant part of Patil *et. al.* (2008).

"Bitran *et. al.* (1986) and Matsuo (1990) proposed enhancements to the classical newsboy problem and computed production sequence and production volume of the style products over the multi period horizon in order to meet entire demand that occurred in the final period. This stream of research did not include the time effects of the costs. Hence, Kurawarwala and Matsuo (1996) further extended this work and considered a more realistic situation where demand was realized over a product life cycle to dynamically determine optimal sourcing quantities.

Quick response research stream used the more refined demand information that is available after product launch and suggested some sophisticated sourcing options (Fisher and Raman, 1996). They modelled the problem as a two stage problem where first ordering decision was made under complete demand uncertainty while the second procurement decision was made after observing the early sales. Given those profits in an apparel industry are about 3% of total sales, their models contributed significantly to the bottom line (Fisher and Raman, 1996).

Recent work that focuses on retailer's inventory management problem for short life cycle product includes Bradford and Sugrue (1990) and Fisher et al. (2004). In both papers, the problem is to determine initial and subsequent replenishment quantities to minimize the cost of lost sales, backorders and unsold inventory. Unlike Bradford and Sugrue (1990) that assumed zero replenishment lead time and used explicit enumeration process to determine optimal order quantities, Fisher et al. (2004) explicitly considered replenishment lead time and also proposed a computationally efficient heuristic to compute order quantities.

The prior research assumes that per unit sourcing cost does not depend upon the ordered quantity. However, it is a common knowledge that a customer can receive a price discount after placing large orders (Silver, Pyke and Peterson 1998). In other words, per unit sourcing cost should decrease with the increase in the ordered quantity. Also, though that the previous research assumes that clearance price remains constant, in some situations, it does depend upon the number of unsold units at the end of the product lifecycle. Clearly, under these situations, monetary risk is lower compared to the situations represented in the prior work. As a result, we believe that both initial and replenishments order quantities can be substantially different in the new situation. This has motivated us to investigate the sourcing problem of the new products when sourcing cost, transportation cost and markdown price decrease with the product quantity."

In addition, Iyer (1999) models a supply chain with a focus on the impact of demand information on demand uncertainty and its impact on demand inventory levels. Instead of assuming demand to be deterministic after a particular stage in the lifecycle, here the uncertainty of demand declines over time as more information becomes available. Though sparse, there is literature support for multi-period progressive price markdowns as a supply chain strategy (Mantrala and Rao, 2001; Talluri and Van Ryzin, 2004).

PROBLEM DEFINITION AND MODEL FORMULATION

Patil *et. al.* (2008, 2010) assume that demand is deterministic once the product has completed some part of its lifecycle. It also considers markdown only in the final stage of the lifecycle. In this paper, we assume that the demand is stochastic throughout the lifecycle though the variability of demand declines significantly over the lifecycle. We also consider progressive markdown as an option through out the lifecycle. We propose a non-linear stochastic programming with recourse formulation to model this problem with the objective of maximizing the retailer's expected product life cycle profit with order before launch of product and its transport batch sizes as decision variables. Also based on demand scenario, the subsequent replenishment orders, their transport batch sizes, and price markdowns are modelled as recourse decision variables.

We assume that the product life cycle, from product launch to withdrawal, could be divided into T retailing periods, where $T = \{t|t = 1,\ldots, T\}$. Each period is of duration k time units. Let p represent the planned unit retail price of the product. This the price at which the retailer would sell the product in period 1. As described in the introduction, the demands in subsequent periods are dependent on the demand of their respective predecessor periods. This implies that if there are three demand scenarios (low, medium and high) in each time period, then for a two time period situation there are nine product lifecycle demand scenarios (3^T scenarios for a T period situation). Let S ($s \in S$) represent the set of all product demand lifecycle scenarios. For scenario s, let d_{ts} represent the demand in period t at retail price p and $\square_s$ represent the probability of this demand scenario. For scenario s, if p_{ts} (price decision variable) represents the actual unit retail price in period t (where $t > 1$ and $p_{ts} \leq p_{(t-1)s} \leq p$) and d'_{ts} represents the product demand in period t at retail price p_{ts}, then $d'_{ts} = d_{ts}(1+\varepsilon[p - p_{ts}]/p)$, where ε is the price elasticity. Let l be the lead-time for procuring material from the supplier such that $k >> l$. We assume that forecasting and material procurement, if any, in a particular planning period happens at k-l time units from the start of that period. As $k >> l$, we assume that the actual demand in a given period can be predicted accurately at k-l time units from the start of that period. Let R, $R = \{r|r = 0,\ldots, T\text{-}1\}$, represent the set of all the time points when forecasts and procurement decisions are made. Then, $r = 0$ refers to a time point that is l time units before the commencement of period 1, while $r = T$-1 refers to a time point that is l time units before the commencement of the last retailing period. Thus, the material ordered in a particular retailing period would be available for sale at the beginning of the next period.

Let $c_r(x)$ represent the procurement quantity discount function that computes the per unit procurement cost of the product for business volume x ordered at time point r. We assume that $c_r(x)x$ is a non-decreasing function of x. Let $u_r(x)$ represent the transportation quantity discount function that computes the per unit transportation cost of the product for a batch size *x* for volume ordered at time point *r*. We assume that $u_r(x)x$ is a non-decreasing function of *x*. Let h_t and w_t represent the inventory holding cost per unit and the backorder cost per unit, respectively, in period *t*. Let i_{ts} and b_{ts} represent the inventory and the backorder quantities, respectively, at the end of period *t* under scenario *s*.

We now define the decision variables other than the price decision variable. Let x_0 represent the initial procurement order placed *l* time units before product launch (speculative order) and x_{0t} the portion of the speculative order received at the beginning of period *t*. Let x_{rs} represent the procurement order placed at time point *r* ($r \geq 1$) under scenario *s* (reactive order) and x_{rst}, where $t > r$, represent the portion of x_{rs} that is received at the beginning of period *t*.

Mathematical Formulation

Maximize:

$$\begin{aligned}&\sum_s \phi_s \left(pd_{1s} + \sum_{t=2}^{T} p_{ts} d_{ts}^{/}\right) - c_0(x_0)x_0 - \sum_s \phi_s \sum_{r=1}^{T-1} c_r(x_{rs})x_{rs} - \sum_t u_o(x_{ot})x_{0t} \\ &- \sum_s \phi_s \left\{ \sum_{r=1}^{T-1} \sum_{t=r+1}^{T} u_r(x_{rst})x_{rst} + \sum_{t=1}^{T-1} \left(h_t i_{ts} + w_t b_{ts}\right) - h_T i_{Ts} + w_T b_{Ts} \right\}\end{aligned} \quad (1)$$

subject to:

$$x_0 = \sum_t x_{0t} \quad \ldots \quad (2A)$$

$$x_{rs} = \sum_{t=r+1}^{T} x_{rst} \quad \forall r \geq 1, \forall s \quad \ldots \quad (2B)$$

$$x_{01} - i_{1s} + b_{1s} = d_{1s} \quad \forall s \quad \ldots \quad (3)$$

$$x_{0t} + \sum_{r=1}^{t-1} x_{rst} + i_{(t-1)s} - b_{(t-1)1s} - i_{ts} + b_{ts} = d_{ts} \quad \forall s, \ \forall t > 1 \quad \ldots \quad (4)$$

$$p_{ts} \leq p \quad \forall s, \ \forall t > 1 \quad \ldots \quad (5)$$

$$p_{(t-1)s} - p_{ts} \leq 0 \quad \forall s, \ \forall t > 2 \quad \ldots \quad (6)$$

$$d_{ts}\left(1 + \varepsilon\left[p - p_{ts}\right]/p\right) = d_{ts}^{/} \quad \forall s, \ \forall t > 1 \quad \ldots \quad (7)$$

where, x_0, x_{0t}, x_{rs}, x_{rst}, $p_{ts} \geq 0$ represent the non-negative constraints.

The mathematical model has a stochastic non-linear objective function (Equation 1) that maximizes expected profit by subtracting expected sourcing, transportation, inventory, backorder and lost sales costs from expected revenue. Constraints 2A and 2B ensure that the total shipment quantity over all periods is equal to the initial (speculative) order and reactive (replenishment) orders respectively. Constraints 3 and 4 indicate the inventory balance equations for period 1 and for the remaining periods, respectively. These equations suggest that under each scenario order backlogs or inventories may be built over the product life cycle, depending upon the realized demand and shipment quantities received in each period. Constraints 5 and 6 indicate that the retail price in a period cannot exceed the launch price and is non-increasing over time. Equation 7 captures the impact of price markdown in each retail period after period 1. Firms may have some excess inventory or unfulfilled demand at the end of the final retailing period *T*. For short product lifecycle products, as the length of the product lifecycle is defined and fixed, excess inventory at end of product lifecycle is salvaged, while unfulfilled demand is treated as lost sales. Hence, for the last planning period, backorder cost and inventory holding cost definitions are adjusted as follows. The unit backorder cost in the last period *T*, w_T, is the unit revenue lost. The unit inventory holding cost in the last period T, h_T, is the unit salvage value. The salvage value is zero if the firm has to dispose the unsold units at the end of the season for free. In situations where the firm can sell the unsold units through other channels, the salvage value would be positive. The solution to the mathematical model thus provides the optimal speculative order quantity, the speculative order's shipment schedule, and the recourse plan (consisting of the optimal reactive order quantity, the reactive order's shipment schedule and the markdown price) for each scenario.

NUMERICAL EXPERIMENTS AND RESULTS

We consider a three period problem for our numerical experiments. We assume three demand scenarios (low, medium, high) in each of the time periods. We also assume that the demand in period 2 and 3 to be related to the demand in their previous periods. This results in 27 demand scenarios. The different scenarios and their corresponding demands and probabilities are as shown in Table 3.

The planned unit retail price is 20. The demand forecasts are for this selling price. The unit backorder for demand backordered in periods 1 and 2 is 1.5 per unit. The demand backordered in period 3 is lost sales which is equal to 20 per unit. The salvage value of material left at the end of period 3 is zero. Linear quantity discount functions were used to represent procurement and transportation costs in our experiments. The unit procurement cost term is $c_r(x) = a_{0r} - a_{1r}\, x$, where a_{1r} such that $c_r(x)$ is a non-decreasing function of x and $a_{00} \leq a_{01}$. The unit shipping cost term is $u_r(x) = e_{0r} - e_{1r}\, x$, where e_{1r} such that $u_r(x)$ is a non-decreasing function of x and $e_{00} \leq e_{01}$. The procurement cost structure for material ordered in periods 1 or 2 is represented as 8 - 0.002x. The transportation cost structures for material dispatched in period 0 is represented as 1 - 0.001x and for material dispatched in period 1 and 2 is represented as 2 - 0.002x.

We tried to understand the impact of various logistics and marketing characteristics — the inventory holding rate, the price elasticity of demand, and speculative order cost structure — on the performance of different supply chain strategies. In the 2x2x2x2 experimental design, we varied these parameters along the following lines. The unit inventory holding cost in periods 1 and 2 are kept at two levels: low = 1 and high = 3. We assume that the launch price is retained in period 1. However, in periods 2 and 3 the retailer could markdown price to increase demand. For our preliminary experiments, we restricted the markdown to two prices, 18 and 15. Constraint 5 represents this relationship between demand and price. Studies point that the price elasticity is usually between 0 and 2 for fashion products (Fadiga *et*. *al*. 2005, Jones and Hayes 2002). In the experiments, we have considered two types of demands —price inelastic and price elastic. The corresponding price elasticity of demand in our experiments is 0.25 and 2.0, respectively. The procurement cost structure for material ordered in period

Table 3: Experiment demand Scenarios

Demand Scenario	Period 1		Period 2		Period 3	
	D	P	D	P	D	P
1					75	0.030
2			85	0.09	85	0.030
3					95	0.030
4					90	0.030
5	50	0.3	100	0.09	100	0.030
6					110	0.030
7					105	0.040
8			115	0.12	115	0.040
9					125	0.040
10					115	0.040
11			125	0.12	125	0.040
12					135	0.040
13					130	0.053
14	70	0.4	140	0.16	140	0.053
15					150	0.053
16					145	0.040
17			155	0.12	155	0.040
18					165	0.040
19					160	0.040
20			175	0.12	175	0.040
21					190	0.040
22					185	0.030
23	100	0.3	200	0.09	200	0.030
24					215	0.030
25					210	0.030
26			225	0.09	225	0.030
27					240	0.030

D: Demand, P: Associated probability0 is varied using the values low = 4, high = 8 for a_{01}, and low = 0.002, high = 0.004 for a_{11}.

DISCUSSION AND CONCLUSIONS

The experiment results are described in Table 4 below. Referring to Table 4, it is seen that in all the 16 experiments splitting the initial order into multiple dispatch consignments is more optimal than dispatching the material as one consignment in the beginning of the product lifecycle. It implies that where inventory holding cost equals or dominates transportation cost, as is in our experiments, it is preferable to split an order that spans demand across many periods into multiple dispatch lots. This is line with JIT practice and is also observed in supply chains for high demand uncertainty products. For such products, inventorying material at a central location (supplier warehouse) is better than having stock of material across many retail outlets. Conversely, when transport costs dominate the product cost structure, it is important for firms to develop local suppliers as sourcing from a low-cost distant supplier may result in supply chain decisions that may not be responsive to the demand uncertainty.

Table 4: Experiment Results

Exp. No.	Business Environment				Optimal Supply Chain Decisions			Increase in profit (%) on base case†
	ε	a_{01}	$h_{t=1,2}$	a_{11}	First Order Split (t = 1, 2, 3)	Further Orders* (r = 1, 2)	Mark-downs* (t = 2, 3)	
1	0.25	8	3	0.002	(70,125,65)	Yes, Yes	No, No	65.0 (2370.3)
2	0.25	8	3	0.004	(70,125,125)	No, Yes	No, No	57.4 (2583.6)
3	0.25	8	1	0.002	(70,160,30)	Yes, Yes	No, No	25.7 (3150.5)
4	0.25	8	1	0.004	(70,190,30)	Yes, Yes	No, No	20.2 (3423.7)
5	0.25	4	3	0.002	(70,95,285)	No, Yes	No, No	40.5 (3733.9)
6	0.25	4	3	0.004	(70,95,400)	No, No	No, No	44.3 (4007.1)
7	0.25	4	1	0.002	(70,155,165)	No, Yes	No, No	11.2 (4757.4)
8	0.25	4	1	0.004	(70,125,370)	No, No	No, No	10.9 (5238.8)
9	2	8	3	0.002	(70,125,65)	Yes, Yes	No, Yes	65.5 (2370.3)
10	2	8	3	0.004	(70,125,140)	No, Yes	Yes, Yes	62.2 (2583.6)
11	2	8	1	0.002	(70,165,25)	Yes, Yes	No, Yes	26.1 (3150.5)
12	2	8	1	0.004	(70,195,25)	Yes, Yes	No, Yes	21.2 (3423.7)
13	2	4	3	0.002	(55,165,245)	No, Yes	Yes, Yes	50.8 (3733.9)
14	2	4	3	0.004	(55,170,340)	No, No	Yes, Yes	56.7 (4007.1)
15	2	4	1	0.002	(70,170,265)	No, No	Yes, Yes	19.3 (4757.4)
16	2	4	1	0.004	(70,205,290)	No, No	Yes, Yes	20.7 (5238.8)

* Yes implies recourse action in some of the scenarios; No implies no action in all the scenarios

† Base case profit (indicated in parentheses in the last column) refers to the optimal profit when only order is placed for the entire product lifecycle (no further orders), the ordered material is received as one consignment in the beginning of the product lifecycle (no order split), and retailer doesn't markdown the price during the product lifecycle.

In experiments 1 to 4 and 9 to 12, where the ordering cost in period 0 is similar to ordering in subsequent periods, follow-up orders in periods 1 and 2 based on better demand information is clearly a preferred strategy. However, in the other experiments follow-up orders are preferred only marginally owing to the big differential in ordering cost if ordered in period 0 vis-à-vis the other periods. In fact, follow-up order in either period is not an optimal strategy in experiments 6, 8, 14, 15 and 16. The experiments indicate that the ordering cost differential has a significant impact on whether a retailer should commit entire demand before product launch or depend on multiple ordering that would enable him to respond accurately to demand.

The demand is price inelastic in experiments 1 to 8. The markdown during the product lifecycle is not a preferable strategy for such demand. However, the demand is price elastic in experiments 9 to 16. It is seen that the markdown during the product lifecycle is an optimal strategy for price elastic demand. The results also highlight the importance of price markdown from intermediate stages of the product lifecycle instead only at the end of the product lifecycle. In the eight experiments (experiments 9 to 16) where markdown is a preferred strategy, there are five experiments where the optimal profit could be further increased owing to the provision for markdown in period 2.

From an exploratory analysis of other findings of the experiments, it appears from the results that offering markdown over a longer part of the product lifecycle with a phased reduction of price is a better strategy than offering markdown only at the end stage. This is because, period to period, a sharper fall in price could be witnessed in the latter case. This in turn could have a negative impact on the customer perception of the product. We would like to study this aspect in more detail and expect our findings to be a significant contribution to work in this research stream.

The experiment results reinforce the findings of Patil *et. al.* (2010) that retailers benefit from price markdowns, order splitting and recourse ordering. We plan to work further on the analytical aspects of our model and the managerial implications of the model proposed.

REFERENCES

1. Bitran, G. R., E.A. Haas and H. Matsuo (1986); Production planning of style goods with high set up costs and forecast revisions; *Operations Research*; 34(2), 226-236.
2. Bradford, J. W., and P. K. Sugrue (1990); A Bayesian approach to the two period style-goods inventory problem with single replenishment and heterogeneous Poisson demands; *Journal of Operations Research Society*; 43(3), 211–218.
3. eCom Online Marketing (2010); iPad Sales Anyone’s Guess as Analysts Skip Estimates; http://www.ecomonlinemarketing.com/blog/?p=304 (accessed April 27, 2010).
4. Fadiga, M.L., S.K. Misra and O.A. Ramirez (2005); US consumer purchasing decisions and demand for apparel; *Journal of Fashion Marketing and Management*; 9(4), 367–79.
5. Fisher, M., and A. Raman (1996); Reducing the cost of demand uncertainty through accurate response to early sales; *Operations Research*; 44(4), 87–99.
6. Fisher, M., K. Rajaram, and A. Raman (2004); Optimizing inventory replenishment of retail fashion products; *Manufacturing and Service Operations Management*; 3(3), 230-241.
7. Iyer, A.V. (1999); “Modeling the impact of information on inventories” in Quantitative Models for Supply Chain Management; S. Tayur, R. Ganeshan, and M. Magazine, eds.; Kluwer Academic Publishers, Norwell, MA.
8. Jones, R. and S. Hayes (2002); The economic determinants of clothing consumption in the UK 1987-2000; *Journal of Fashion Marketing and Management*; 6(4), 326–39.
9. Kurawarwala, A.A., and H. Matsuo (1996); Forecasting and inventory management of short life cycle products; *Operations Research*; 44(1), 131-150.

10. Mantrala, M.K., and S. Rao (2001); A Decision-Support System that Helps Retailers Decide Order Quantities and Markdowns for Fashion Goods; *Interfaces*; 31(3), S146-S165.
11. Matsuo, H. (1990); A stochastic sequencing problem for style goods with forecast revisions and hierarchical structure; *Management Science*; 36(3), 332-347.
12. Patil, R., B. Avittathur and J. Shah (2008); Ordering strategies for short product life cycle made-to-stock products; Proceedings of the 13th ISL (Bangkok, July 6-8, 2008), pp. 387-394.
13. Patil, R., B. Avittathur and J. Shah (2010); Supply chain strategies based on recourse model for very short life cycle products; *International Journal of Production Economics*, Accepted for publication (http://dx.doi.org/10.1016/j.ijpe.2010.01.025).
14. Raman, A. (1999); "Managing inventory for fashion products" in Quantitative Models for Supply Chain Management; S. Tayur, R. Ganeshan, and M. Magazine, eds.; Kluwer Academic Publishers, Norwell, MA.
15. Silver, E.A., D.E. Pyke, R. Peterson. 1998. Inventory Management and Production Planning and Scheduling. New York: Wiley.
16. Talluri, K.T., and G. Van Ryzin (2004); The Theory and Practice of Revenue Management; Springer Science+Business Media, Inc.

ANTECEDENTS OF SUPPLIERS' WILLINGNESS TO INVEST IN RFID

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ABSTRACT
This study aims to extend the adopting rate model of DOI to examine the channel behaviour of non-dominating suppliers and compare the channel effect with conventional innovation factors in adopting RFID. Data from 130 Taiwanese suppliers for local retail chains were collected. Partial least square (PLS) was established to calibrate the effects of the constructs identified using VisualPLS version1.04b1. Results conclude that institutional influences have no effect on suppliers' RFID adoption intention. Alternatively, they indirectly affect the suppliers' intentions in investing in relationship with retailers. Further, the relational investment may significantly affect the suppliers' organizational readiness that places some effects on adoption intention. In general, the channel effects are greater than those of innovation characteristics for suppliers' adoption intention. The results place a great emphasis on channel management in future technology promotion, development, and adoption.

Keyword: Institution theory, RFID adoption, Channel behaviour

INTRODUCTION

Inter-organizational systems (IOS) is an automated information systems shared by two or more companies. A key emphasis of these IOS is to improve the coordination between buyers and suppliers through electronic integration (Glover and Saeed, 2007). The advent of RFID systems was considered as an enabler of supply chain efficiency to facilitate the communication across inter-organizational integration (Spekman and SweeneyII, 2006). It is now attracting considerable attention from a number of major retailers. Wal-Mart, and Target Corporation had all mandated that their key suppliers be RFID-enabled by the end of 2006.

Supply chain are, in most cases, championed by network leaders of retailers that have power over their suppliers and orchestrate the channel members to control resources (Duffy, 2008). Because the adoption of IOS requires cooperation between two organizations, the relationship between an organization and its partner is salient (Huang, et al., 2008). Diffusion of innovation (DOI) is often used to explicate organizational IT adoption. It proposed a theoretical framework that identifies the relationship between perceived innovation attributes and the intention of adoption (Jeyaraj, Rottman and Lacity, 2006). Innovation, environment and organization are three main classifications justified to affect the adoption intention of an IOS. However, the extant literature was almost focused on the perspective of retailers, a dominating channel member of a supply chain. Behaviors of a non-dominating supplier in adopting an IOS were grossly overlooked.

In today's economy characterized by global networks of firms, successful inter-organizational relationships (IORs) are critical for supply chain performance (Barringer and Harrison, 2000). Influence, relational and structural factors are concluded as three main drivers for channel member with their IOS decision (Hausman et al., 2005). For a non-dominating supplier, its IOS adoption may come from the effects of its retailers' influence, or/and its intention of investing in retailer to form a credible commitment to the relationship (Son et al., 2005), and this intention may affect its organizational structure of adopting an IOS. However, these channel effects are not properly described and compared with conventional adoption factors for non-dominating suppliers. Analytical model is absent and empirical evidence is lacking.

As a result, this study aims to extend the adopting rate model of DOI to examine the channel behaviour of non-dominating suppliers and compare its effect with conventional innovation factors in adopting RFID. Instead of coercion/non-coercion influence, we applied institutional theory that suggests three influence mechanisms of institutional isomorphism: including coercive, mimetic, and normative (DiMaggio and Powell, 1983) to more comprehensively express the channel influence. This study may answer the following research questions: Would the institutional influences directly affect the RFID adoption intention of a non-dominating supplier? Would the influences affect its intention of relational investments that may indirectly affect the RFID adoption intention? Would the relational investment intention also affect its organizational readiness that further energizes the effect of organization in adoption? Finally, in general, how significance of the channel effects, comparing with the conventional innovation characteristics, affect non-dominating suppliers in adopting RFID?

Instead of conducting a case study analysis, this study searches for statistical evidence from the retail industry on demand side of the supply chain that has few been explored, in particular in developing countries (Brown and Russell, 2007). Data from 130 Taiwanese suppliers for local retail chains were collected. These were major suppliers in terms of market share and financial capability, and with the existing IOS systems with retailer established, such as e-procurement, and information sharing system, they are regarded as the potential forerunner of future RFID project. In using the data, partial least square (PLS) was established to calibrate the effects of those constructs identified. Reliability and validity of data were tested and path analysis was calibrated using VisualPLS version1.04b1.

This study fills a gap in the literature, where prior work has seldom used empirical research to describe how the channel behavior of non-dominating suppliers affects an IOS adoption and compare its effects with conventional innovation attributes. The expansion of the relationship between the channel behavior and technology adoption intention may effectively identify enablers and inhibitors of technology innovation in retail chains. Empirically, the perspective on RFID adoption among Taiwanese retailers reflects the general attitude of such firms toward the adoption of new information technology. The results of this research may have implications for retailers and their suppliers, as well as and RFID manufacturers, in future technology promotion, development, and adoption.

THEORIES AND HYPOTHESES

Innovation characteristics

Diffusion of innovation (DOI) is widely used to explicate information technology adoption of an organization (Jeyaraj, Rottman and Lacity, 2006). DOI proposed a theoretical framework that identifies the relationship between perceived innovation attributes and the rate of adoption. Rogers (1983) proposed some characteristics influencing DOI as relative advantage, complexity, compatibility, trialability and observability. In the organizational level, factors that importantly influence an organization's willingness to adopt a new technology are relative advantage, technical complexity (Agarwal and Prasad, 1998). The relationship is indicated in hypotheses H1 and H2.

H1. Relative advantage is positively associated with the intention towards RFID technology adoption.

H2. Complexity is negatively associated with effects on the intention towards RFID technology adoption.

Channel effects

Recently, relationship context, power exercised, and institutional environment were identified as critical factors. The relationship can be grossly explained by institution theory (Duffy, 2008; Fang et al., 2008; Son et al., 2005).

According to institution theory, isomorphic pressures facing suppliers may involve coercive, mimetic, and normative pressures (DiMaggio and Powell, 1983). Pressure or power sources originated from industries, governments, and cultures can influence organizational structure and operations (DiMaggio and Powell, 1991). There is strong empirical support for institutional-based variables as predictors of adoption intentions for interorganizational linkages in previous studies (Teo et al., 2001; Teo et al., 2003). We hypothesize three positive correlations as indicated in hypotheses H3a, H3b, and H3c.

H3a: Coercive pressures are positively associated with the intention towards RFID technology adoption.

H3b: Mimetic pressures are positively associated with the intention towards RFID technology adoption.

H3c: Normative pressures are positively associated with the intention towards RFID technology adoption.

When suppliers suffer some institutional pressures from outside the organizations, they may consider investing in relationship. The reciprocal investments made by a firm tend to promote long-term and stable relationship with its business partner in an exchange relationship by encouraging the partner into increasing the level of cooperation (Son et al., 2005). We hypothesize three positive correlations as indicated in hypotheses H4a, H4b, and H4c.

H4a: Coercive pressures are positively associated with relational investment.

H4b: Mimetic pressures are positively associated with relational investment.

H4c: Normative pressures are positively associated with relational investment.

Research indicated that the investment could enhance the effectiveness of inter-organizational innovation (Fang et al., 2008). Previous studies conclude that relational investment (RI) may increase benefits of adopting IOS. For example, Krause and Ellram (1998) indicated that benefits of closer relationships are access to suppliers' best technology, and increases switching costs of retailers. Subramani et al (2003 and 2004) indicated that RI confers suppliers with advantages over competitors, and it can create exit barriers for the retailer and it overhauls suppliers' bargaining power as well. A RI provides significant avenues for the acquisition of resources and strategic benefits such as cost and risk reduction (i.e., complexity) (Jarillo, 1998). The bundle of knowledge and skills that an organization has to acquire for innovation can be assimilated effectively (Rogers, 1995). RI has a positive relationship with intention of adoption. Suppliers typically depend on a few dominant trading partners, like retailers, for a majority of their revenues (Hart and Saunders, 1997). RI will help to sustain the relationship that is a source of resource and revenue. Such external support may help supplier to overcome resource shortage and enhance the organizational readiness. In prior research, the success of innovation adoption is dependent on an organization's preparation for the innovation (Huang et al., 2008). Successful IOS implementation occurs when sufficient organizational resources (sufficient developer and user time, sufficient funding, sufficient technical skills, etc.) are directed, first toward motivation, then toward sustaining the implementation (Kwon and Zmud, 1987). We hypothesized the relationship between RI, intention of adoption and organizational readiness as:

H5: Relational investments are positively associated with the intention towards RFID technology adoption..

H6: Relational investments are positively associated with organizational readiness.

H7: Organizational readiness is positively associated with the intention towards RFID technology adoption.

Together, seven hypotheses are structured to illustrate the antecedents and consequences of suppliers' BI toward an IOS adoption. The framework is indicated as Figure 1.

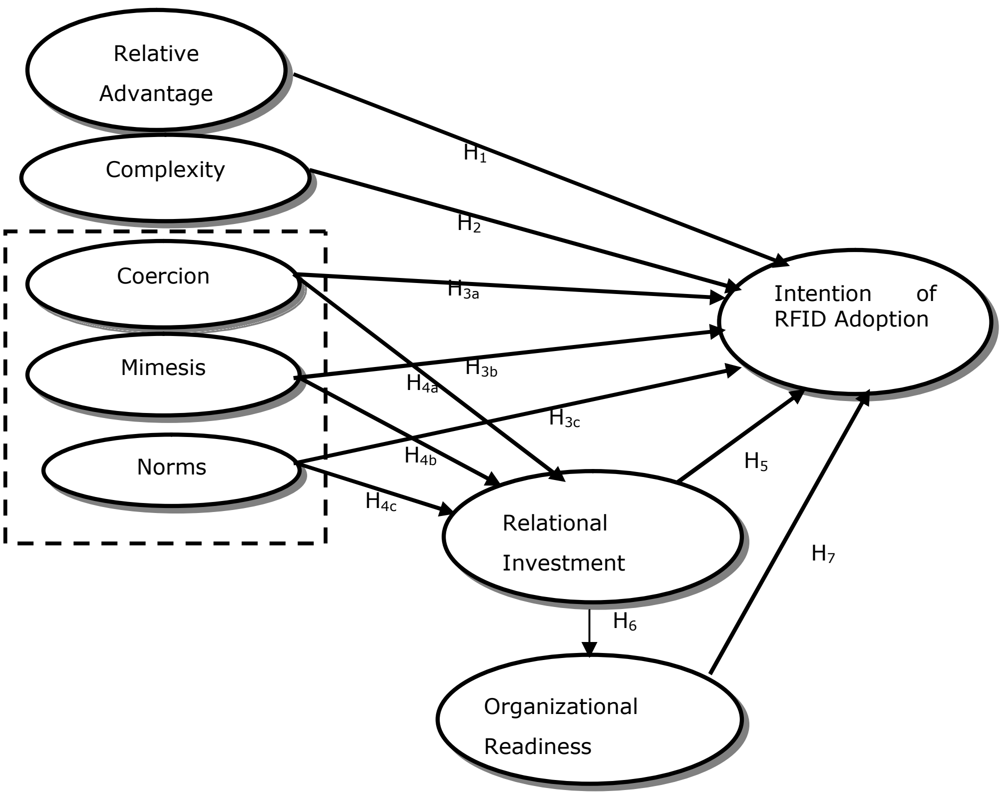

Fig 1: Analytical Model

DATA COLLECTION

Our tested suppliers were selected from a medium-sized retail chains in Taiwan. The retail chain estimated that 222 suppliers (56%) belong to self-centered type, and 176 suppliers (44%) belong to the rest types. We chose the latter as our questionnaire respondents as a result of their highly cooperative relationship with retailers, from 398 suppliers.

A questionnaire was developed to gather data from the suppliers of general merchandises retailer stores, which include convenience stores, supermarket, hypermarkets, department stores, and other general merchandises stores. The questionnaire was designed to indicate the importance of 34 statements associated with the manifestations of the eight constructs identified in the previous section. Items used in the questionnaire to manifest the constructs of the model were adopted from prior researches with changes in wording appropriate for RFID adoption. A pilot test done by 6 senior managers from both suppliers and supermarket retailers was carried out to confirm whether our factors are critical to the industry and to modify statements if necessary. All of the items were measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The survey was conducted over a period of 5 months between November 2008 and March 2009. According to our focus group interview with six senior managers from both suppliers and retailers, there were approximately 600 suppliers providing merchandises or services for general merchandise retail chains in Taiwan. Of these suppliers, their industrial customers were highly overlapped among supermarkets, hypermarkets, convenience stores, department stores and other retailers. A total of 398 suppliers of a celebrated retail chain were selected as sampling object. The questionnaires were collected from176 suppliers having close cooperation with retailers. After removing invalid questionnaires, 130 (65%) questionnaires were remained. For each survey, face-to-face interviews or telephone interviews were used to ensure respondents' understanding of the questions asked. The respondents were carefully selected to ensure credible results. Among them, 64% of respondents were division manager or above with an average tenure in the supply industry of 13.5 years. The total annual returns averaged US$47.45 million per firm. The merchandises provided by the suppliers involve fresh foods, groceries, home appliances, house wares, apparels and other merchandises as well. Information systems, which were commonly used including e-procurement, POS, supply chain systems.

ANALYSIS AND RESULTS

The proposed model and hypothesis testing was conducted by using partial least square (PLS) with visualpls version 1.04b1 (Fu, 2006). The PLS approach (Barclay et al., 1995; Chin, 1998), like other structural equation modeling (SEM) techniques such as LISREL and EQS, allows researchers to simultaneously assess measurement model parameters and structural path coefficients. Chin (1997) and Majchrzak et al. (2005) have suggested that the sample size shall be at least 5–10 times large of largest path number in the path model. In our model, the largest path model was 11 and the sample size of this study was 130, which conformed to the PLS estimation procedures.

The result summary was shown as Table 1. As Chin (1998) recommended, bootstrapping (with 500 subsamples) was performed to test the statistical significance of each path coefficients by using t-tests. The estimation was done through re-sampling of the sample and was more precise than that was estimated by limit approximation.

The results exhibit that H1 is supported. Relative advantage is positively associated with the intention towards RFID technology adoption (β=0.106, $p<$ 0.01).H2 is supported. Complexity is negatively associated with effects on the intention towards RFID technology adoption (β= -0.192, $p<$ 0.001). H3a, H3b, H3c are not supported. Institutional pressures are positively associated with the intention towards RFID technology adoption (βa=0.006, βb=-0.044, βc=0.022, ns).H4a, H4b, H4c are supported. Institutional pressures are positively associated with relational investment (βa=0.354, βb=0.206, βc=0.236, $p<0.001$ and $p<$ 0.05).H5 is supported. Relational investment is positively associated with the intention towards RFID technology adoption (β=0.410, $p<0.001$). H6 is supported. Relational investments is positively associated with organizational readiness (β=0.867, $p<$ 0.001). H7 is supported. Organizational readiness is positively associated with the intention towards RFID technology adoption (β= 0.748, $p<$ 0.001).

Table 1: Analytical results of PLS

	Hypotheses	Path coefficient	t-value	Result
Innovation factors				
H1	Relative advantage → Intention of RFID adoption	0.200	3.597***	Supported
H2	Complexity → Intention of RFID adoption	-0.198	-3.080**	Supported
Influence factors				
H3a	Coercion → Intention of RFID adoption	0.001	0.051	Not
H3b	Mimesis → Intention of RFID adoption	-0.069	-1.710	Not
H3c	Norm → Intention of RFID adoption	0.058	1.606	Not
H4a	Coercion → Relational investment	0.355	4.431***	Supported
H4b	Mimesis → Relational investment	0.209	2.207*	Supported
H4c	Norm → Relational investment	0.234	2.249*	Supported
Relational factors				
H5	Relational investment → Intention of RFID adoption	0.786	14.316***	Supported
H6	Relational investment → Organizational readiness	0.798	32.278***	Supported
Structural factors				
H7	Organizational readiness → Intention of RFID adoption	0.428	4.878***	Supported

* t- value > ∣1.96∣, P < 0.05. ** t- value > ∣2.58∣, P < 0.01. *** t- value > ∣3.29∣, P < 0.001.

CONCLUSION

Several findings of this study are indicated. The major findings of this study exhibits that institutional isomorphic pressures have no effect on suppliers' RFID adoption intention. Alternatively, they indirectly affect the suppliers' intentions in investing in relationship with retailers. Among the three institutional isomorphic pressures, all have significant effects on suppliers' relational intention. It indicates the rational investment can better account for the adoption intention than influence. As previous theoretical perspectives, suppliers' relational investments on their customers mainly stem from their dependences upon the critical resources their customers possess and the fear of power over them exercised by their customers (Duffy, 2008). Further, relational investments are considered to be assets in terms of transaction cost economics because they present a powerful means for suppliers to create value and confers supplier firms with advantages over their rivals within that industry (Subramani, 2004). In addition, relational investments made by suppliers can be used to create exit barriers for the retailers and overhaul the bargaining powers of suppliers (Ghosh and John, 1999).

Further, the relational investment may also significantly affect the suppliers' organizational readiness that places on some adoption effect. In general, the channel effects are greater than those of innovation characteristics for suppliers' adoption intention. Between the innovation characteristics, suppliers therefore emphasize on the challenges facing them rather than the expected benefits because RFID is relatively a state-of-the-art system.

The study results provide crucial future strategic orientations for retailers to deploy RFID systems and come to a consensus between two parties, and for supplier to understand the viewpoint perceived by the majority of the industry. In addition, this work also helps retailers identify the potential complexities they perceive and address the expected benefits that suppliers are likely to obtain by making RI in deploying RFID systems.

There are several limitations in this study. First, study results merely reflect Taiwanese perspectives. Different cultural contexts with different environmental settings may have generated different results. In addition, surveys targeting organisation representatives tend to have a lower response rates than those targeting individuals (Baruch, 1999). A larger sample that brings the more statistical power would have allowed more sophisticated statistical analysis. In addition, RFID technology is still maturing and the industry is young. Its full impact is not yet foreseeable and there is still much promise for the future. Further research is recommended to compare the results of the adoption intention of industry over time.

REFERENCES

Agarwal, R., and Prasad, J. (1998). "A conceptual and operational definition of personal innovativeness in the domain of information technology". Information Systems Research, Vol. 9, NO.2, PP.204-215.

Barclay, D., Higgins, C. and Thompson, R. (1995) "The partial least squares (PLS) approach to causal modeling: Personal computer adoption and use as an illustration". Technology Studies, 2, pp.285-309.

Baruch, Y. (1999), "Response rate in academic studies: a comparative analysis," Human Relations, Vol.52, No.4, pp. 421-438.

Brown, I., and Russell, J. (2007), "Radio frequency identification technology: An Exploratory study on adoption in the South African retail sector", International Journal of Information Management, Vol., 27, No. 4, pp. 250-265.

Chin, W. W. (1997), Overview of the PLS method.

Chin, W.W. (1998), "The partial least squares approach to structural equation modeling", In: Marcoulides, G.A. (Ed.), Modern Methods for Business Research, Lawrence Erlbaum Associates, Mahwah, NJ, pp. 295–336.

DiMaggio, p., and Powell, W. W. (1983), "The iron cage revisited: institutional isomorphism and collective rationality in organizational fields", American Sociology Review, Vol. 48 NO. 2, pp. 147-160.

DiMaggio, P.J. and Powell, W.W. (1991), The iron cage revisited: institutional isomorphism and collective rationality in organization fields, in: W.W. Powell, P.J.

Duffy, R. S. (2008), "Towards a better understanding of partnership attributes: an exploratory analysis of relationship type classification", Industrial Marketing Management, Vol. 37, PP.228-244.

Fang, S. R., Wu, J. J., Fang, S. C., Chang, Y. S., and Chao, P. W. (2008), "Generating effective inter-organizational change; a relational approach", Industrial Marketing Management, Vol. 37, PP. 977-991.

Fu, J. R. (2006). "VisualPLS 1.04b1", Taiwan: National Kaohsiung University of Applied Sciences.

Ghosh, M. and John, G. (1999), "Governance value analysis and marketing strategy" Journal of Marketing, Vol. 63, PP. 131- 145.

Grover, V. and Saeed, K. (2007), "The impact of product, market, and relationship characteristics on inter-organizational system integration in manufacturer- supplier dysds", Journal of Information Systems, Vol. 23 NO. 4, PP. 185-216.

Hausman, A., Johnston, W.J., and Oyedele, A. (2005), "Cooperative adoption of complex systems: a comprehensive model within and across networks," Journal of Business & Industrial Marketing, Vol. 20, NO.4, PP.200-210.

Huang, Z., Janz, B.D., and Frolick, M.N. (2008), " A comprehensive examination of internet-EDI adoption", Information Systems Management, Vol. 25, PP. 273-286.

Jarillo, J. C. (1998), "On strategic networks", Strategic Management Journal, Vol. 9, No. 1, PP. 31-41.

Jeyaraj, A., Rottman, J. W. and Lacity, M. C. (2006), "A review of the predictors, linkages, and biases in IT innovation adoption research", Journal of Information Technology, Vol. 21 NO. 1, PP. 1-23.

Krause, D.R. and Ellram, L. (1998), "Supplier development: a collaborative approach", European Journal of Purchasing and Supply Management, Vol. 3, PP.21–32.

Majchrzak, A., Beath, C. M., Lim, R., & Chin, W. W. (2005), "Management client dialogues during information systems design to facilitate client learning", MIS Quarterly, Vol. 29 NO.4, PP. 653–672.

Rogers, E. M. (1983). "Diffusion of Innovation", 3rd ed. New York: The Free Press.

Rogers, E. M. (1995), "Diffusion of Innovations", Free Press, New York.

Son, J. Y., Narasimhan, S., and Riggins, F. J. (2005), "Effects of relational factors and channel climate on EDI usage in the customer-supplier relationship", Journal of Information Systems, Vol.22 NO. 1, PP. 321-353.

Spekman, R. E., and Sweeney II, P. J. (2006), “RFID: from concept to implementation”, International Journal of Physical Distribution & Logistics Management, Vol. 36 NO.10, PP. 736-754.

Subramani, M. and Venkatraman, N. (2003), “Safe-guarding investments in Asymmetric inter-organizational relationships: Theory and evidence,” Academy of Management Journal, Vol. 46 No. 1, PP.46-62.)

Subramani, M. (2004), “ How do suppliers benefit from information technology use in supply chain relationships?”, MIS Quarterly, Vol. 28 NO. 1, PP.45-73.)

Teo, H.H., Tan, B.C.Y., and Wei, K.K. (2001), “Factors influencing the adoption of IT-based interorganizational linkages: an integrative perspective,” Working Paper, Department of Information Systems, National University of Singapore.

Teo, H.H., Wei, K.K., and Benbasat, I. (2003), “Predicting intention to adopt interorganizational linkage: an institutional perspective,” MIS Quarterly, Vol.27, NO.1, PP. 19-49.

INTEGRAL DATA PROVIDING SOLUTION FOR CONTAINER SUPPLY CHAIN EFFICIENCY AND VISIBILITY

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ABSTRACT
This paper provides an overview how to integrate IT technologies with modern business processes, taking into consideration existing international transport regulations and legal and administrative changes that are still in the developing process. The article presents an approach how to enhance supply chain visibility and at the same time support logistics operators in Business-to-Customs cooperation processes with the purpose to a better reliability and predictability of transport processes. Furthermore, the study describes the unique neutral data integrating IT platform SICIS and its contributions in improvement of a global supply chain security, visibility and efficiency. Besides general managerial insights, this paper provides trade stakeholders and customs authorities with information about a tool that could be used for securing intermodal container chains on door-to-door basis by evaluating information from different information sources (CSDs, RFID, vessel and vehicle monitoring systems, etc.) and enables to create the full-scale integrated IT system.

Keywords: Supply Chain Visibility, Security It Platform, Container Logistics, Container Security Devices.

INTRODUCTION
Nowadays logistic container transport systems connect worldwide ports and consumer markets, manufacturing and distribution centres, as well as production and processing facilities via unique intermodal, economic and organizational integration. Logistic transport systems involve a huge amount of transport-supporting documentation. Furthermore, new security restrictions/regulations affect the smooth economic and organizational integration of the transport system as a whole. The transport system integration process is characterized currently by increasing of transport system complexity, which includes simultaneously several challenges like increasing dynamics of involved logistics systems, bottlenecks in transport modes connections as well as new security restrictions/regulations for cargo shipments and customs processing in the ports (2010b, P Crist et al., 2005, HH Willis and DS Ortiz, 2004).

Additionally, since 2001, a variety of different unilateral and multilateral security regulations and legislative initiatives has been developed or are under consideration. However, first attempts have been made by the US with the programmes OSC (Operation Safe Commerce) and SST (Smart and Secure Trade Lanes). Given that world trade is largely dependent on maritime transport, much of the focus has been directed at enhancing maritime transport security and at addressing the particular challenges posed by containerised transport (2004). Transport authorities identify several criminal and terrorist-related challenges in container transport system. These illegal activities include theft of goods and vehicles, fraud, illegal immigration, drug and contraband smuggling, potential targeting dangerous goods and terrorist activities. Changes in security have also created new opportunities to strengthen import/export control of any type of containers along the supply chain of the maritime transport sector. Import/export control is strengthened through negotiations in the new organizational field of maritime transport security.

DESCRIPTION OF THE CASE STUDY

This paper addressed to the increased demand among supply chains providers to secure their tradelines and satisfied new safety and security global regulations/rules. Different measures, such as the introduction of the ISPS code in 2004 and the C-TPAT programme in the US, enhanced the security in parts of the international intermodal chain, but a worldwide approach covering the chain from origin to destination is still missing.

Based on the existing tendency to secure global trade from industry and authorities sides, the project INTEGRITY ("Intermodal Global Door-to Door Container Supply Chain Visibility"), funded by the European Commission, DG Research, intends to develop an IT system serving both issues at the same time by creating supply chain visibility(N Meyer-Larsen, 2009).

INTEGRITY is an integration project. Although a lot of building blocks are exist, most of the above mentioned technologies have been run through technical feasibility tests without tackling the integration into a common concept on the level of business processes, legal and administrative changes and possible incentives when using them in a consistent and reliable manner. An important step towards secure operators is the EU Customs Code issued by the Directorate-General Taxation and Customs Union (DG TAXUD) with its AEO (Authorised Economic Operator) approach. Cooperation between Customs Authorities in the SSTL (April 2008) project between EU and China Customs Authorities is closely linked to INTEGRITY project. Therefore, issues of the Customs-to-Customs cooperation will be attempted also from the industry's perspective supporting Customs-to-business and business-to-business cooperation. The combination of existing technologies and new business processes together with legal and administrative agreements between administration/Customs and industry/logistics will create a win-win situation for both target groups.

INTEGRITY has one of the goals to investigate how to integrate innovative technologies (Container Security Devices (CSDs), RFID, e-seals) with the new EU customs authorities' regulations (e-customs procedures). The Shared Intermodal Container Information System (SICIS) has been created in this project to allow fast and reliable access to the data along a supply chain for port community systems, shipping lines, port authorities, and logistics operators. The challenge for INTEGRITY is to integrate different components of complex transport system as a whole one. Therefore, the paper describes the data integrated approach with a strong focus on concurrently enhancing the supply chain security and improvement of logistic processes along the trade line China-Europe.

The INTEGRITY project aims at improving the trustworthiness and predictability of global door-to-door container transportation in the China-EU trade corridor. This aim is to be achieved through cooperation between transport industry and Customs Authorities in the EU and China (2010a).

In the project the cooperation opportunity of logistics operators in Business-to-Customs cooperation is considered. In order to specify the macro-environment of the created SICIS (Shared Intermodal Container Information System) special integral data providing solution for supply chains we have approached this by the LoNGPESTEL analysis (K Daschkovska et al., forthcoming 2010, J Kay and R Rothschild, 1993).

Table 1 highlights main environmental challenges regarding the technology development and national and international processes regarding the INTEGRITY project. The fundamental changes have been developed in the political/legal and technological area. Those main challenges extremely affect the technology development in the INTEGRITY project.

	LOCAL	NATIONAL	GLOBAL
Political	▪ EU e-Customs Initiatives ▪ E-documentation initiatives by EU ▪ Standardization of documents and electronic data requirements	▪ E-Government Model ▪ New security and safety-focused international/national frameworks	▪ IMO and WCO new standards and procedures ▪ WTO negotiations on trade facilitations ▪ US international security initiatives
Economic	▪ Simplification of EU customs procedures ▪ Reductions in cargo delays through more effective regimes	▪ Harmonization and facilitation of EU and international trade ▪ Transparent and operable procedures for supply chain stakeholders	▪ Overseas economic growth ▪ Collaboration business-to-business (B2B) and consumer-to-business (C2B)/business-to-consumer (B2C)
Social	▪ Avoidance of transport document duplication ▪ Time-release measures for customs procedures in EU	▪ aim is simple and transparent rules and procedures ▪ tendency towards automation of trade documents exchange	▪ crucial role of trade documents in international supply chains ▪ International electronic transport documentation/information exchange
Technological	▪ Single Window concept for EU ▪ EU process for standardization of trade documents	▪ Single Windows frameworks implemented in different countries ▪ International EDI requirements for trade data ▪ Standardization issues on national markets	▪ Development of ICT in the world market ▪ Combination of pros and cons from available technologies (RFID, CSD, GPS/GPRS etc) ▪ International Standardization issues
Environmental	▪ Reduction in paper-based communications	▪ EU safety and secure transportation	▪ Safety and Security impacts on global supply chains
Legal	▪ New EU Customs Code ▪ ICS/ECS	▪ EU Single Window Concept ▪ AEO concept ▪ AIS/AES	▪ The WCO Customs Data Model ▪ WCO SAFE Framework of Standards ▪ The UN/CEFACT Integrated Framework of Standards for Paperless Trade ▪ IMO ISPS Code ▪ CTPAT initiative

Tab. 1: LoNGPESTEL analysis of the macro-environment in the INTEGRITY project

For instance, the EU government expects potential benefits for both economic operators and customs services from modernizing customs legalization (2008). The Automated Import System (AIS) and Automated Export System (AES) together with NCTS (New Computerised Transit System) aim at easing the customs procedures (export, import and transport) by avoiding duplication at the EU level (2007). The AIS/AES aim to ensure that import/export operations started in one Member State can be completed in another Member State without re-submission of the same information. This includes the exchange of electronic messages related to the different stages of the operations amongst the various stakeholders (customs, traders and other governmental administrations). The ICS/ECS (Import and Export Control Systems) are the parts from the new customs modernization concept "Single Window" (2005) as well as the first stage for implementation of AIS/AES, which require appropriate data sets for the customs pre-arriving or pre-departure cargoes' clearance processes (2006). Furthermore, the SAFE Framework of the World Customs Organization addresses a list of measures which should be implemented, e.g. to shift customs processes from the import to the export side – however, an integrated approach is still missing (June 2007).

The crucial part of the project is the development of the Shared Intermodal Container Information System, which allows authorized companies and authorities to access planning and status information of selected consignments. The innovative SICIS has been created taking into account the new EU customs regulations (e-customs procedures) and considering the development of container security technologies (container security devices, RFID, e-seals).

INTEGRATED SOLUTION FOR CONTAINER SUPPLY CHAINS

The technical innovation of SICIS consists of the fact that every kind of CSD resource can be used to trigger information. SICIS has the ability to receive the information and to deal with it (2010a). Furthermore, the development of the SICIS (Fig. 1) is specified by the simultaneous modernization process in the EU customs system.

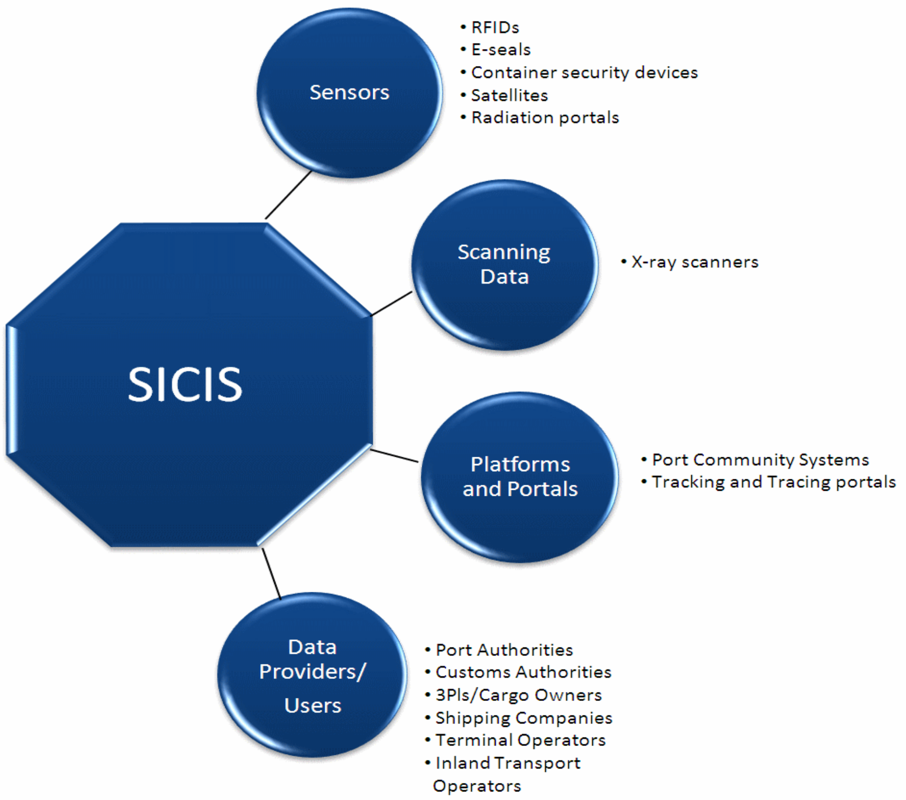

Figure 1: The Shared Intermodal Container Information System (SICIS)

The Import Control System and Export Control System are the part of the new e-customs modernization concept 'Single Window'. They require appropriate data sets for pre-arriving or pre-departure cargo clearance processes. The Shared Intermodal Container Information System that has been created in the INTEGRITY project can provide fast and reliable access to required containers' data along a logistic transport chain for customs authorities and trade partners. The data flows accompanying the transport must be integrated to optimize the Customs clearance (Fig. 2). The integration of the data in the e-customs model or in general the adoption process for the complete SICIS system will require the cooperation with the involved Customs authorities and thus a dialog between the users and the project members in the technology development phase.

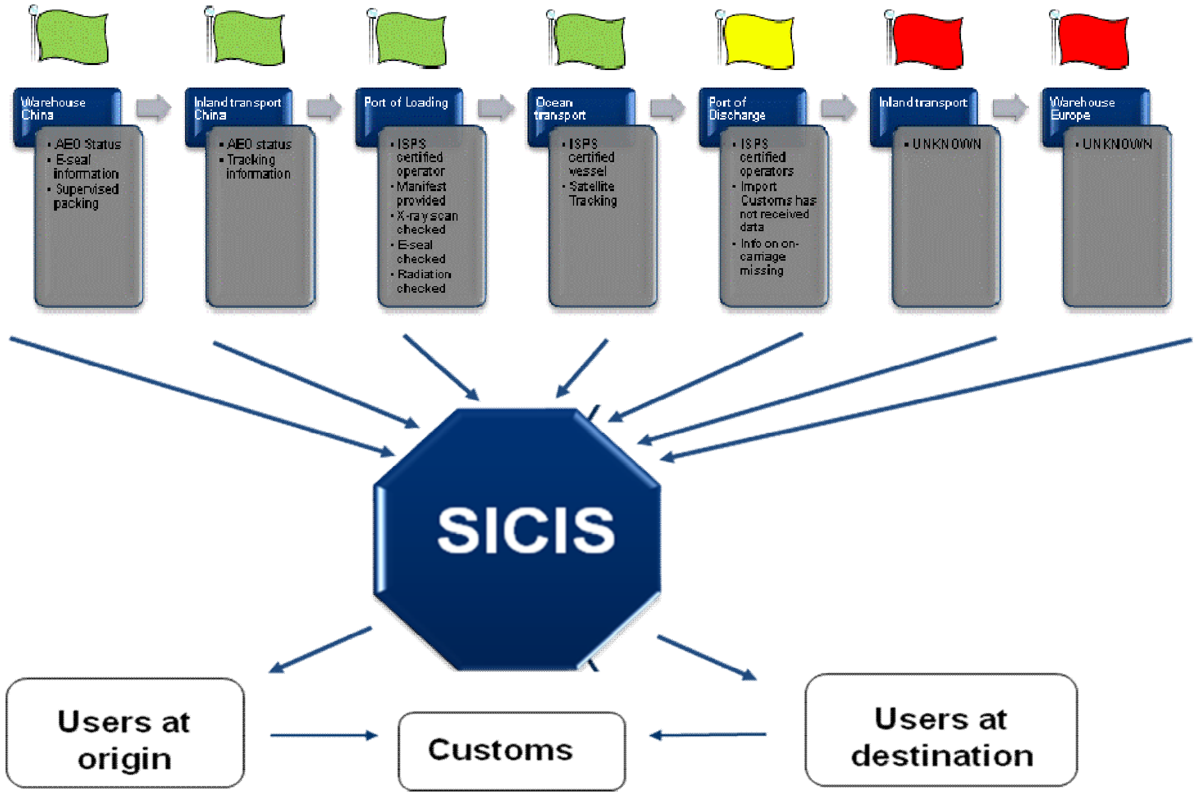

Figure 2 SICIS information flows overview

UN/CEFACT Recommendation 33 is that "a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfill all import, export and transit related regulatory requirements. If information is electronic, then individual data elements should only be submitted once." This means that the International Trade Single Window system can support different business ICT solutions as it complies with data definitions and other protocol specifications (2009). The SICIS IT system can support business operators to provide required trade data to the authorities in more sufficient and convenient way. The information from the SICIS can be directly submitted to the appropriate controlling organizations in electronic form.

With the SICIS it is feasible as well to track container routes along the entire transport logistic transport chain and to register all events generated by the terminals involved. The technology development of the SICIS platform is divided into the following three phases:

- Phase I: In September 2009 the INTEGRITY project network implemented the SICIS IT platform, which provides the registered logistics operators with on-demand tracking information during the transport.
- Phase II: Since the beginning of 2010 the extended version of the basic SICIS is able to link container monitoring data with vessel tracking information provided by satellites using the vessels' AIS signals (Automatic Identification System) (2010c, Feb. 2010).

- Phase III: The future version of SICIS will be improved to include even more innovative functions. The forthcoming SICIS IT platform will be able to link existing data from container monitoring with consignment information relevant for Customs.

The optimisation of customs clearance and commercially-important containers' tracking processes is demonstrated with two of SICIS innovative processes. The creation of the SICIS IT platform has been planned based on the existing tendency in the EU and worldwide to simplify, standardize and computerize the trade information flows. The SICIS is a system that integrates different ICT innovations (such as RFID, radiation portals, X-ray scanners) via appropriate IT portals and systems. This integrated system provides container tracking data for various system users or logistic operators. Significant improvement of transport chain transparency as well as the predictability of the transport processes can be achieved by mean of the SICIS integral solution.

CONCLUSION

INTEGRITY is an integration project on technology and processes with a strong focus on data integrity. The expected benefits are significant: door-to-door chains will become more secure and smooth. All target groups (3PLs, cargo owners, exporters, transport and port operators, Customs authorities) will be satisfied in one approach. The full-scale integration of IT systems along the chain will enable the creation of the so-called Shared Intermodal Container Information System (SICIS) containing either the data itself or links to the data providers (such as port community systems, shipping lines, port authorities). This combination of information flows in SICIS allows fast and reliable access to the planning data and status information of selected transports.

Specific analyses on the benefits for all players in the chain analysing actual bottlenecks and performing before-after comparisons including the related costs for such a service will be part of the project. The supply chains stakeholders can acquire the potential benefits:

- planning of hinterland logistics (data available for each mode of transport and hinterland destination for on-carriage; planned dwell time information can be used for storage planning by the terminal operators)
- Reduction of administrative errors (more accurate, timeliness and accessible information)
- Safety stock reduction (real-time information if container is loaded / unloaded)
- Integration of the whole supply chain (integrity of shipment, monitoring of flow via SICIS and ability to query shipment data increases trustworthiness and provides basis for reduced inspections)

Furthermore, SICIS will pro-actively inform the relevant user if possible risks were detected during the transport process. The Customs Authorities can also use SICIS for detection of "risk- containers". An important issue is the careful handling of the data which for the first time is consolidated in the described manner. The neutral design of SICIS allows its connection to any other system like port community systems or existing legacy systems, hence data security must be ensured at any time.

To conclude, this paper has been concentrated on the INTEGRITY project contribution to make container supply chains more secure, predictable and reliable through the providing of business partners and customs authorities with the transport data in accurate, reliable, timely and value adding form. The paper has discussed as well some already existing and currently developing solutions for secure and efficient intermodal transport systems. The concept of INTEGRITY presented in this paper introduces the new configuration of next generation of supply chains under the grief "trust but verify".

REFERENCES:

(2004) "Container Security: Major Initiatives and Related International Developments", by The United Nations Conference on Trade and Development (UNCTAD), UNCTAD/SDTE/TLB/2004/1**,** 48. Available at: http://www.unctad.org/en/docs/sdtetlb20041_en.pdf.

(2005) "Recommendation and Guidelines on establishing a Single Window to enhance the efficient exchange of information. Recommendation No. 33.", by United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) New York and Geneva**,** pp. 33. Available at: <http://www.unece.org/cefact/recommendations/rec33/rec33_trd352e.pdf>.

(2006) "Fact Sheet. The WCO Customs Data Model – Version 2.0", by World Customs Organisation (WCO). Available at: http://www.wcoomd.org/files/1.%20Public%20files/PDFandDocuments/Procedures%20and%20Facilitation/CustomsData_Model_ENG.pdf.

(2007) "Communication from the Commission. Freight Transport Logistics Action Plan", by Commission of the European Communities (COM 2007), Brussel. Available at: http://ec.europa.eu/transport/logistics/freight_logistics_action_plan/doc/action_plan/2007_com_logistics_action_plan_en.pdf.

(2008) "The Community Customs Code (CC), implementing provisions and guidelines - Current legal provisions", by European Commission, Taxation and Customs Union, Web Site. Available at: http://ec.europa.eu/taxation_customs/customs/procedural_aspects/general/community_code/index_en.htm.

(2009) "SITPRO. The Simpler Trade Procedures Board. New conceptual model for International Trade Single Window, Version 1.1, 24 July 2009.": Available at: http://www.sitpro.org.uk/regreview/newitsw.pdf

(2010a) "3rd INTEGRITY Newsletter ": Available at: http://www.integrity-supplychain.eu/index.php?module=News&func=display&sid=21.

(2010b) "INTEGRITY Project Web Site": Available at: http://www.integrity-supplychain.eu/.

(2010c) "INTEGRITY Project Web Site. 3rd INTEGRITY Newsletter": Available at: http://www.integrity-supplychain.eu/index.php?module=News&func=display&sid=21.

(April 2008) "Regional Best Practice Study on Authorized Economic Operator (AEO)", by WCO ROCB Asia Pacific**,** pp. 15. Available at: http://www.wcoasiapacific.org/wcoweb/board/download.jsp?systemid=ROCB&boardid=rocb_bp&seq=2&sub_seq=0.

(Feb. 2010) New version of SICIS combines container monitoring and AIS vessel-tracking. In *ICT Online* Available at: http://www.porttechnology.org/Security%20+%20Logistics/New-version-of-SICIS-combines-container-monitoring/5589.html.

(June 2007) "WCO SAFE Framework of Standards", by World Customs Organization. Available at: http://www.wcoomd.org/files/1.%20Public%20files/PDFandDocuments/SAFE%20Framework_EN_2007_for_publication.pdf.

CRIST, P., CRASS, M. & MIYAKE, M. (2005) Container Transport Security Across Modes. European Conference of Ministers of Transport and Organisation for Economic Co-operation and Development.

DASCHKOVSKA, K., PFEFFERMANN, N., MEYER-LARSEN, N. & HUELSMANN, M. (forthcoming 2010) Adoption Framework for Innovations in Logistic Transport Chains. *Hamburg International Conference of Logistics 2010, Innovative Processes and Solutions in Logistics and SCM.* Hamburg, Germany, ERICH SCHMIDT VERLAG GmbH & Co.

KAY, J. & ROTHSCHILD, R. (1993) "*Foundations of corporate success: How business strategies add value"*, Oxford University Press Oxford.

MEYER-LARSEN, N. (2009) "Heading towards transparency: creating supply chain visibility to improve container transport", in *PORT TECHNOLOGY INTERNATIONAL,* 41 (Sept.)**,** pp. 109-111.

WILLIS, H. H. & ORTIZ, D. S. (2004) Evaluating the Security of the Global Containerized Supply Chain. The RAND Corporation.

CARGO INTELLIGENCE FOR INTERMODAL OPERATIONS

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ABSTRACT:
The ongoing research project EURIDICE (European Inter-Disciplinary Research On Intelligent Cargo For Efficient, Safe And Environment-Friendly Logistics) focuses on the development of intelligent solutions for the transport sector. The basic concept of EURIDICE is an information services platform centred on the individual cargo item, and on its interaction with the surrounding environment and the user. This paper continues the research presented in the ISL2009 with an analysis of the Intelligent Cargo (IC) concept and how the concept might be implemented in intermodal transport chains.

Keywords: intermodality, Intelligent Cargo, decision support system

Introduction and background

The logistics industry is extreme fragmented when the majority of the players in the industry are small and medium enterprises, and 80% of road haulage goes to micro-companies. Large players are subcontracting most low-value activities. On the other hand, the logistics industry is today facing sustainability challenges, when trucks are absorbing 35% of total road fuel production with an expected increase to over 40% by 2030,. Also transport-related CO2 emissions are at a level of 23% and rising (EURIDICE White Paper, 2009).

The solution for lowering transport-related CO2 emissions is the utilisation of rail for cargo operations. Railways perform a significant portion of the associated operations and are known for their ability to offer cost-effective long-haul transportation services (Bektas et al 2009). The share of rail of all commercial freight transportation within the United States and EU has only exhibited a very slight increase over the last 15 years, and remains today at a share of 27% of all freight transportation (Bektas et al 2009). In some cases, rail transport is not possible, and then it is reasonable to use the most suitable transport mode. This paper focuses on the intermodal operations which are defined as "the movement of goods in one and the same loading unit or vehicle which uses successively two or more modes of transport without handling of the goods themselves in changing modes" (United Nations, 2001).

Intermodal logistics uses the benefits of its constituent transportation modes to deliver a competitive service compared to the traditional over-the-road (OTR) networks (Macharis and Bontekoning, 2004). Intermodal logistics offers opportunities that go beyond an alternative to truckload (TL) shipments, but on the other hand intermodal services are designed for less-than-truckload (LTL) shipments as well (Ishfaq and Sox, 2010).

This paper is continuation of the papers presented to the Institute of Shipping Economics and Logistics (ISL). The first paper presented the idea of intelligent agent technology for supporting Intelligent Cargo realisation (Schumacher et al. 2009). The second paper was about the management and decision making in intermodal operations (Hemilä, 2009). As stated above, the transport sector needs some new approach to enhance stakeholders' business. The new technologies should be implemented, and different transport modes should be used as effectively as possible. This paper focuses on intermodal operation as one of the most environmentally friendly transport modes, with the implementation of the newest technologies for cargo movement management. In the ongoing research, we are realising the Intelligent Cargo concept in different end-user cases. One end-user case is about intermodal transport.

Methodology
The research is based on the constructive research methodology, according to which a new construct for Intelligent Cargo in intermodal operations will be developed, implemented and tested within a single case study (Yin, 2003). The paper discusses how intelligence could support the businesses of transport sector companies and other transport-related stakeholders. This research is part of the FP7 project called EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-Friendly Logistics). EURIDICE is about the development of ICT solutions for transportation and intelligent cargo. Our pilot application is for an intermodal operator in Finland.

State of the art Cargo Intelligence for the transport sector
The tracking of shipments, materials, and products has been recognized in the operations management literature both as a problem in practice and as a potentially important tool for improving inventory management and operations performance (Holmström et al. 2010). Tracking is not enough but the entire visibility of the transport from cargo to back office systems. Information and Communications Technologies are key to sustainable logistics and transport. It is important to remember that ICT are enablers for solutions, rather than solutions in themselves. Crainic et al (2009) have argued that Intelligent Transportation Systems (ITS) developments have up to now been 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. 2009). They add that in order to reach the full potential of ITS, one must thus address the challenge of making the most intelligent use possible of the hardware that is being deployed and the huge wealth of data it provides (Crainic et al. 2009). Crainic et al. (2009) have posed two critical questions: Are all of these data transformed into useful information, and: Is this information properly exploited? We have had similar findings from our research but also from practice. We realised that markets offers many solutions for track and tracing. Radio Frequency identification (RFID) has been a hot topic for research and practitioners for over a decade. The overall solutions for transport management are now under development.

At the moment, there are many ongoing projects in Europe for improving visibility for supply chains, and the project focus is slightly different in each case. Smart Container Management develops neutral, a service platform which enables secure and interoperable B2B and B2A data communications in global door-to-door container transport management (SmartCM, 2010). The objective of the SMARTFREIGHT project is to develop new traffic management measures towards individual freight vehicles through open ICT services, on-board equipment and integrated wireless communication infrastructure (Smartfreight, 2010). The Freightwise project's overall objective is to support the modal shift of cargo flows with the improved management and facilitation of information access and exchange between large and small, public and private stakeholders across all business sectors and transport modes (Freightwise, 2010). The common idea in these ongoing projects is the development of a platform for transport management. The platform collects data from a shipment by using track-and-trace technologies and the back office solution uses data for management purposes.

One of the ongoing transport-related European Commission-funded projects is EURIDICE. The vision of EURIDICE is stated as: "In five years time, most of the goods flowing through European freight corridors will be "intelligent", i.e. self-aware, context-aware and connected through a global telecommunication network to support a wide range of information services for logistic operators, industrial users and public authorities." The EURIDICE concept is turning the management idea upside down, with the idea of cargo managing itself. Cargo communicates with surrounding environment, organises its transport and follow-up itself according to set targets. Cargo informs the back office system when something goes wrong or does not go as planned. Situations like deviation from a predefined route, too high a temperature in the cargo, or some other target value exceeding accepted limits, are the impulse to the transport management for corrective action. EURIDICE has defined Intelligent Cargo as: "… a set of technologies, knowledge and tools provided by the EURIDICE infrastructure to support advanced analytics and knowledge-based applications to help better understand the complex cargo domain in a broader business, environmental and social context" (EURIDICE White Paper, 2009). Intelligent Cargo has several features compared to state-of-the art dumb cargo as presented in Table 1.

Table 2 Intelligent Cargo capabilities

Capability		**Dumb Cargo (state of the art)**	**Intelligent Cargo**
Basic	Self-identification	• Local identification based on the proprietary systems of each actor. • Shared IDs through ad-hoc connection between back-office systems. • Pre-fixed level of detail throughout the supply chain.	• Global identification provided by public domain services. • Cargo is able to self-identify through a common infrastructure, accessible to field users, vehicles and the back-office. • Dynamically selected level of detail (package, pallet, container).
	Context detection	• No self-standing context detection capability. • Context is extrapolated by back-office systems accessing other information sources (e.g., local ID repository).	• Context determination provided by public domain services. • Common infrastructure, providing context data (identification details, location, time) to authorized users.
	Access to services	• No direct access to services from the cargo itself. • Services managed by proprietary systems of each actor or by generic (not cargo related) platforms.	• Common infrastructure, providing access to services to authorized users or systems interacting with the cargo.
Advanced	Status monitoring and registering	• Sensing and data storing at a specific cargo level (e.g. container). • To go beyond raw data, ad hoc back-office elaboration is needed.	• Status data are available in real time through the service infrastructure. • Status data are contextualized and integrated with the other cargo information services.
	Independent behaviour	• No such capability.	• Cargo is able to invoke services and start processes autonomously in response to predefined events.
	Autonomous decisions	• No such capability.	• Cargo has decision-making capabilities and is able to choose services to invoke according to circumstances.

EURIDICE is developing software platform and hardware modules realising the Intelligent Cargo vision. The software platform will be common to all kind of transport management. The EURIDICE approach consists of making cargo information services available to the broad spectrum of potential users, by lowering adoption barriers related to cost, effort and information system requirements. The EURIDICE platform is open and scalable, where users will have the option to use and extend EURIDICE services gradually, from data acquisition to automated transactions, intelligent data analysis and decisions support (EURIDICE White Paper, 2009).

Eight pilot scenarios have been selected in order to test the EURIDICE infrastructure and technologies on real cases, with the aim of demonstrating the Intelligent Cargo concept and its advantages. Each scenario refers to a precise business context and problem to be solved. The aim, of course, is not to cover all the possible activities in a generic transport process, but rather to map varying relevant situations where Intelligent Cargo can be put into practice to the benefit of various stakeholders (EURIDICE White Paper, 2009). Figure 1 presents the overall EURIDICE pilot scenarios. This paper is about pilot scenario number 6 “Cargo-assisted intermodal transport” and it is about intermodal wagon operation in the selected case of the intermodal operator in Finland.

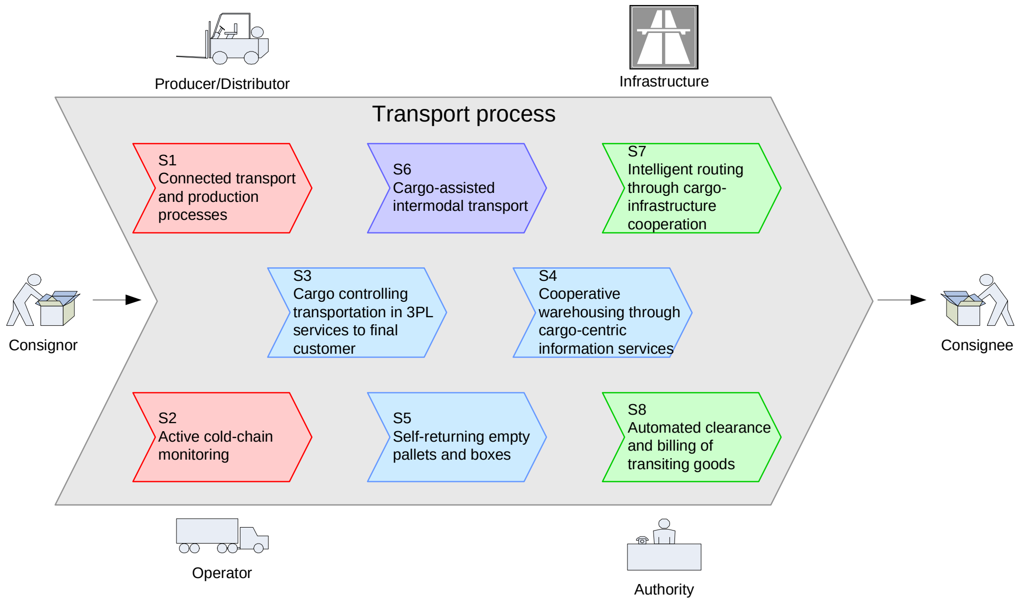

Figure 3 EURIDICE pilot scenarios (EURIDICE White Paper, 2009).

Each pilot case will have its own specific application running across the platform. The hardware part is also provided. EURIDICE will test different hardware units in the pilot cases, starting from simple RFID temperature recording to Intelligent Module at the Cargo Unit level. EURIDICE includes different levels of hardware implementation, dependent of the level of cargo hierarchy. The basic cargo level is the item level, where a single item might include bar codes, RFID or other identification technologies for ensuring cargo identification. The pallet level consists of various items together. On that level, identification and communication is only carried out for pallets, not on the single item level. The next level is the Unit level, where pallets or items are located inside one unit, typically a container or wagon. Below Figure 2 presents the idea of EURIDICE Cargo Hierarchy.

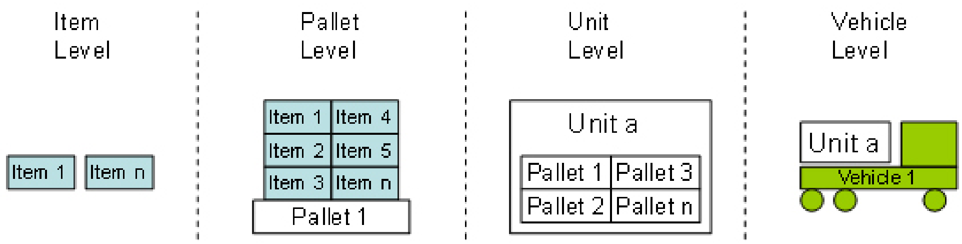

Figure 4 Cargo hierarchy in freight movement

This paper is about the intermodal operator pilot case in the EURIDICE project. The Intelligent Cargo concept is realised on the Unit level, where the intermodal operator manages the flow of wagons and means units in the cargo hierarchy. The cargo units are moved in the supply chain with a vehicle, which is the highest hierarchy level in the EURIDICE freight movement context. The following chapter provides a detailed description of the pilot case.

A practical example of Cargo Intelligence for intermodal transport

In the cargo-assisted intermodal transport pilot, the Intelligent Cargo focus is on the cargo unit level in terms of follow-up of the railway wagons. The intermodal supply chain consists of wagons whose axels have to be changed in Finland because of the different rail gauge there compared to other European countries. The cargo itself is loaded once in the wagon at the consignor's location and unloaded at the final destination. The Unit (wagon) uses various types of transport modes, when the vehicle changes during transport. Figure 3 presents the idea of the intermodal supply chain in the pilot, where the cargo is loaded onto the railway wagon and same wagon is moved by different vehicle during the transport process.

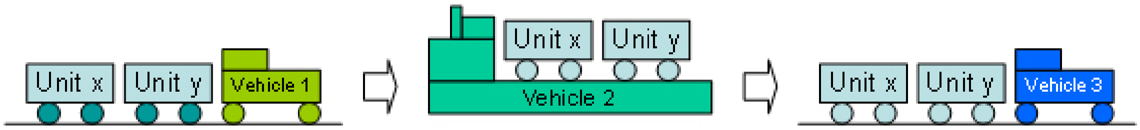

Figure 5 Cargo level approach in pilot context

The intermodal operator pilot enriches the EURIDICE approach to Intelligent Cargo. This pilot is not a typical track and tracing approach. It deals with the management of unit level movements of cargo. Today the movement of railway wagons is a "black box" from the intermodal operator point-of-view. Individual stakeholders have various ICT tools for managing freight movement, but the information is not visible to the intermodal operator. With EURIDICE, the business of the intermodal operator could be enhanced by creating visibility for wagon movement. The EURIDICE platform provides automated wagon selection and management, but also automated alerting and event information originating from IC. According to the data received from the actual transport process, the system calculates key performance indicators for intermodal operation.

The pilot concerns traffic in Scandinavia – more precisely, from Finland to Norway (via Sweden). Currently, the intermodal operator provides transport services, especially for the pulp and paper industry, or other bulk transport needs, typically using leased wagons. The transportation time (typically 4-7 days in Scandinavia) is a well-accepted fact by all parties, and has been taken into account, for example, in production planning by the consignor and the consignee. Shorter lead-times would benefit every stakeholder in the intermodal operation. An efficient information flow could enhance the competitiveness of the intermodal business.

The core business for the intermodal operator is the effective utilisation of the wagon fleet, both long-term leased and wagons leased on a case-by-case basis. Real-time information about the transport process is a key issue in improving intermodal operations efficiency and the utilisation of the wagon fleet. Today, a main challenge is the lack of information about wagon movements. The pilot idea is to enhance the visibility of the wagon movements by realising the intelligent cargo concept. Exact real-time information about the wagons could support activities to increase wagon utilisation rates and consequently the performance of their operations, which is the main business target for the pilot. In many cases, the available information in intermodal operations is:

- old and unreliable
- based on queries to various monitoring solutions/systems in various organizations
- unnecessary in normal circumstances, when no deviations occur

Without reliable up-to-date status information, efficient operative management of the transportation is impossible. Immediate knowledge and alerts about deviations, disturbances and other events are necessary for decisions about fast corrective actions. These present features cause longer lead-times and turnaround times in wagon loading and unloading. According to the real-life challenge in the intermodal operations, and the advantages coming from the EURIDICE Intelligent Cargo capabilities, the pilot objective has been formulated as:

ICT services support for efficient decision-making in intermodal wagon operations

The main objective is broken down into three sub-objectives:

1. Facilitating the proposal of wagon selection
   Automation of the wagon selection proposal on the basis of the order coming from the legacy system and wagon status, condition, position and prediction of estimated time of arrival
2. Automated alerting and event information about the wagon situation
   Wagon sends the notification or alert, if the conditions inside the wagon are not within the predefined limits, as well as being able to check other necessary measures concerning the wagon. The wagon also sends out an alert when it is off the pre-defined transportation route. The wagon send information about the preliminary ETA and any changes in it, and the user must be able to check the ETA when needed.
3. Automated calculation of utilisation rates
   The goal is to monitor wagon utilization in order to acquire the necessary data for decision-making to, e.g. increase the turnaround of the wagons.

For realising the main and sub-objectives of the pilot, we have created the "To Be" process, which includes the idea of improved and lean intermodal process with the following general features:

1. Electronic and automatic information flow, including real-time information to all necessary parties in the transport processes. Duplicate operations should be eliminated from the transport process through the aid of more fluent information flow, and the remaining operations should be performed more easily. Automatic data flow reduces the risk of errors significantly, as well as the amount of work compared with manual data transfer. Wagon selection could be done with online information, where the system itself could make suggestions to the transport planner, based on real-time information with regard to available wagons and transport-need information.
2. Information in unexpected situations. The system is aware of the situation in the wagons on a real-time basis. Intelligent wagons monitor selected issues during transport and inform EURIDICE Platform when something unexpected happens.
3. The real-time location and status of the wagon. The wagon information includes the tracking and tracing information, and information about the state of the wagon. The state of the wagon in turn includes information on whether the wagon is empty or loaded, and possibly information about the cargo inside. The status information also includes, for example, temperature, humidity and g-force information from the intelligent wagon. In problem situations, the alarm or notification would be sent to the actors involved.

With the Cargo Intelligence infrastructure and technologies, the EURIDICE project will contribute to the development of the transport sector.

Concluding Discussion and Future Work

In the EURIDICE vision, Intelligent Cargo connects to logistics service providers, industrial users and authorities to exchange transport-related information and perform specific services whenever required along the transport chain. This will produce significant benefits for the logistics industry and for the community, by an 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. Secondly, Intelligent Cargo is increasing the efficiency of freight transportation networks, by improving synchronization between cargo owners, logistics services and control authorities. Thirdly, it improves the sustainability of logistics, systems, by reducing their impact on local communities in terms of traffic congestion and pollution (EURIDICE White Paper, 2009).

The EURIDICE approach demands a paradigm change in the transport industry. Next Table 2 is about the current paradigm, and how Intelligent Cargo ideology aims to change the paradigm.

Table 3 Change of paradigm in the transport sector (Paganelli, 2009)

	Current paradigm	**Intelligent Cargo**
Data origin	User or back-office generated.	Item/sensor generated.
Interaction paradigm	Organization-to-organization	Thing-to-thing.
Data processing	Centralized at organization level.	Distributed, may start at object level.
Communication support	Predefined communication channels.	Self-configuring combination of local and global communication resources.
Data interchange semantics	Mutually agreed with each partner or between trade community members.	Globally established, for any-to-any ad hoc exchanges.
Decisions support	Top-down decision-making, based on periodic data revision.	Event-triggered, decentralized and (partially) automated exception resolution.

The business of the intermodal operator managing railway wagons will change a great deal after the implementation of the EURIDICE Intelligent Cargo infrastructure. The following business benefits can be defined:

- Cost reduction, less duplication of work and time-consuming queries, shorter lead times and better customer service based on the information available from the intelligent wagon
- Awareness of cargo status at any time right along the chain, which helps to reduce damage and clarify liability issues
- Better planning based on information about deviations, ETA updates, etc.
- Faster and more reliable communication between various actors involved in the supply chain, using common information from the IC and EURIDICE platform.
- Better short- and long-term management of intermodal transport with the help of accurate and necessary information about transport history.
- Environmental benefits, especially with the aid of wider possibilities for intermodal transport.

The EURIDICE project is now over half way completed. The platform design is now defined, and developers are creating parts of the infrastructure. Later this year the platform and technologies will be implemented in the test scenarios of the pilot end-users. At the moment, all the pilots are defining the as-is situation in key performance indicator figures. During the evaluation of the system to-be measurements will be carried out. Then we will be able to define the real business advantages that the EURIDICE infrastructure and the realisation of Intelligent Cargo can provide for transport industry.

References

Bektas T, Crainic T G and Morency V (2009) "Improving the performance of rail yards through dynamic reassignments of empty cars". Transportation Research Part C: Emerging Technologies, Volume 17, Issue 3, June 2009, pp. 259-273

Crainic T G, Gendreau M and Potvin J-Y (2009) "Intelligent freight-transportation systems: Assessment and the contribution of operations research" Transportation Research Part C: Emerging Technologies, Volume 17, Issue 6, December 2009, pp. 541-557

EURIDICE White Paper (2009) "EURIDICE Project White Paper". Available: www.euridice-project.eu (adopted 12.1.2010)

Freightwise (2010) "Management framework for intelligent Intermodal Transport". Project webpage: http://www.freightwise.info (adopted 25.4.2010)

Hemilä J and Kettunen O (2009) “The challenge for decision making in intermodal supply chains”. Proc. of the 14th International Symposium on Logistics (ISL2009). Istanbul, Turkey, 5-8 July, 2009. Nottingham University. UK (2009), p. 709

Holmström J, Främling K and Ala-Risku T (2010) “The uses of tracking in operations management: Synthesis of a research program”. International Journal of Production Economics, In Press, Corrected Proof, Available online 31 March 2010

Ishfaq R and Sox C (2010) “Intermodal logistics: The interplay of financial, operational and service issues”. Transportation Research Part E: Logistics and Transportation Review, In Press, Corrected Proof, Available online 12 March 2010

Macharis C and Bontekoning Y M (2004) “Opportunities for OR in intermodal freight transport research: A review”. European Journal of Operational Research 153 (2), pp. 400–416.

Paganelli P (2009) “The Intelligent Cargo Concept in the European Project EURIDICE”, Presentation in the 2nd European Conference on the ICT for Logistics. Venice, Italy 29.10.2009.

Schumacher J, Gschweidl M and Rieder M (2009) “Using mobile agent technology for fulfilling the vision of Intelligent Cargo”. Proc. of the 14th International Symposium on Logistics (ISL2009). Istanbul, Turkey, 5-8 July, 2009. Nottingham University. UK (2009), 709

SmartCM (2010) “Smart Container Management -project”. Webpage: http://www.smart-cm.eu/ (adopted 25.4.2010)

Smartfreight (2010) “Smart Freight Transport in Urban Areas -project”. Webpage: http://www.smartfreight.info (adopted 25.4.2010)

United Nations (2001) “Terminology on combined transport”, United Nations Economic commission for Europe (UNECE), New York and Geneva. Available: http://www.unece.org/trans/wp24/documents/term.pdf. (Adopted January 7th, 2009).

Yin R (2003) “Case study research - design and methods”. 3rd edition, Applied social research methods series; v. 5. Sage Publications, Inc. 2003

TRANSLATING SUSTAINABILITY FROM STRATEGY TO OPERATIONS: HOW CAN DECISION SUPPORT MODELS HELP LOGISTICS SERVICE PROVIDERS TO ATTAIN STRATEGIC AS WELL AS OPERATIONAL GOALS?

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ABSTRACT
Decision Support Models could help Logistic Service Providers as a means to make transportation more sustainable. When researching this hypothesis, we discovered that Logistic Service Providers were reluctant to use Decision Support Models when making transportation more sustainable. In this paper we show the preliminary results of a survey amongst Logistic Service Providers on how they see the role of sustainability for their business, what issues do influence their decisions on sustainability, and how they perceive the use of Decision Support Models as a tool to make transportation more sustainable.

INTRODUCTION

Environmental issues enjoy wide attention, and government, companies and institutions have incorporated sustainability in their business strategies (De Ron 2001; McDonough & M. Braungart 2002). It should not come as a surprise that it also features on the agenda of many logistics decision making processes (Ploos van Amstel 2008). On the question what is meant by sustainable transportation many different opinions exist (Pezzey 1997), but the most common aspect seems to be the reduction of greenhouse gasses like CO2 and particles (Pieters & Herder 2009). In order to aid Logistic Service Providers (LSP) to reduce these greenhouse gasses, many decision support models (DSM) have been built by researchers and consultants, on own account, or to the order of the authorities. These DSM's are meant, to help decision makers in the field of transportation when considering attaining the sustainability of existing networks, or developing new, more sustainable networks. Examples of these DSMs are Transtools developed by the European Union and Digiscan developed to the order of the Dutch Government (Pieters et al 2009). They all aim to support strategic decisions on how to set up more sustainable transportation networks.

For a DSM to be successfully used, it should provide means of evaluating the trade-offs between various alternatives and arrive at an optimal set of solutions (Moynihan 1995; Van der Vorst 2000; Palmer 2007). But searching for an optimum two problems have to be met: 1) The multi-level feature of design decisions and 2) The coordination problems within the supply network (Schneeweiss 2003). A complication is that measuring the environmental effects of transportation on all levels of decision making (strategic, tactical or operational (Braat 1991) is difficult or even impossible (Bell & Morse 2003).

Researching the value of DSMs for sustainable transportation business strategies in the Netherlands, we discovered that Digiscan was the only known DSM, but was hardly used anymore in case additional external consultancy was not available. Consultants and student did use this tool, but LSPs, as the intended user group, had lost its interest for this DSM. Understanding why a once successful DSM for sustainable transportation, like Digiscan, failed to be used anymore by the intended user group, could clarify what LSPs want from a DSM for sustainable transportation. This could help us to build DSMs that could be really effective in their support for realising more sustainable forms of transportation.

SUSTAINABLE TRANSPORTATION

In order to realize sustainable transportation, the LSP can rely upon the following practical measures:

- Use of environmental friendly transport vehicles
- Use of environmental friendly fuels
- Measures to raise the load factor
- More uses of environmental friendly transport modalities for interregional transport, such as rail or ships
- Reduction of transport by investments in:
    - Combining flows of goods
    - Adapting the warehouse locations
    - Using route planning systems
- Investments in environmental friendly buildings.
- Purchase of environmental friendly goods and services (e.g. green energy)
- Other measures such as training of the employers on sustainability, stimulation of driving economical, reduction of travel, environmental friendly lease cars etc.

A large impact on sustainability could be expected from the use of more intermodal transport. The European Commission (2004) valued the total external costs of road transport concerning long distances to be double compared to rail transport, and 5 up to 6 time to river barge and short sea shipping. The last decades had been characterized by an enormous increase of freight transport. This increase had been linked with an always larger percentage of the road transport in the total transport volume, with the consequence of growing congestion problems and pressure on the environment. Since the 1990´s both the European Union and the Dutch government have tried to stimulate intermodal transport, especially by subsidy regulations and liberalization of rail transport and inland shipping. In the Netherlands a fine network of inland terminals exists. The increase in the transshipment at these terminals however relies on the increase of the maritime container transport and not on the use of intermodal transport to the hinterland. Up to that point the clear improvement of the infrastructure has not resulted in an enlargement of the market share of intermodal transport. This confirms the assumption that state policy only has a facilitating function; the eventual decision concerning the use of intermodal transport is in with hands of the market parties (Macharis 2007).

RESEARCH SCOPE AND METHODOLOGY

That leads us to our question whether and how information and (calculation) tools can help LSPs in reaching their aims in the field of sustainability, including raising the use of alternative transport modalities. For this purpose, we have sent a questionnaire to small and medium (SME) LSPs, in order to find an answer on the next question:

How do logistical service providers translate their strategic policy in the field of sustainability into activities on tactical and operational level and which role plays intermodal transport?

As a basis for this research we have formulated three hypotheses:

Hypothesis 1 (strategic level)	Sustainability is an essential component in the strategic (transport) policy of logistical service providers, but this policy is insufficiently translated to durable intermodal transport networks.
Hypothesis 2 (tactical level)	When drawing new, or changing existing networks in terms of sustainability, little attention is given to intermodal transportation.
Hypothesis 3 (operational level)	When transport tasks are implemented by the LSP, the customer will judge them on speed and costs, rather than on sustainable intermodal transport.

Based on these hypotheses, we have developed a survey for small and medium sized LSPs. We expect that especially within this group of LSPs, a need exists for a DSM in order to help them with environmental issues. Large international LSP's are provided with their own tools, supporting their decisions for setting up their intermodal, sustainable networks. The survey contained three types of questions:

1. Questions concerning the role of sustainability in the mission and vision of the LSP, and its motivation to incorporate sustainability into its strategic policy. And the role that intermodal transport questions plays in these decisions.

2. Questions concerning the influence of customers, competition, logistical service and costs on decisions at operational level.

3. Questions concerning the motivation to set up models for intermodal networks and the use of several types to support these decisions.

We invited 40 LSP to answer these questions in order to get significant results. Unfortunately at the moment of writing this paper the survey had been answered by just 13 LSP. So it is only possible at this moment to give some indications concerning the expected outcomes. Also for this reason the findings concerning the correctness of the hypotheses are provisional.

PROVISIONAL RESULTS FROM THE SURVEY

The role of sustainability in the strategy of a LSP

Sustainability seems to be an aspect in the strategic policy of most (85%) LSPs. Motivation to work on sustainability, beside taking social responsibility (54%), has mainly been based on external pressure: improvement of the company's image (32%), customer demand (32%) and reacting to measures of the government (32%). Although intermodal transport is considered by 54% of the respondents, it plays almost no role in the operational phase (just 15%). The respondents rather try to achieve sustainability with measures such as stimulating economical driving (85%), the reduction of transport (77%), combining flows of goods (62%) and more environmental friendly vehicles (62%).

The influence of customers, competition, logistical service and costs on transport decisions at operational level

On the one hand the market seems to be invoked as an argument to incorporate sustainability in the company´s policy (32%) and is frequently mentioned as a basic condition to get in new customers (46%). On the other hand 38% state that there is little chance of losing customers due to not being sustainable. Building durable transport strategies appears problematic. The main reasons given for this are that the customer:

- is not prepared to pay extra for sustainability (92%);
- will not make concessions on the speed of the transport (85%);
- will not aid the LSP considering optimizing the transport by planning the supply chain differently (62%).

The LSPs themselves indicate that they react proactively to sustainability (92%) and are open for cooperation with competitors on this issue (85%), but they expect the willingness of these colleagues to cooperate with them to be low (54%). This indicates that they have a more positive idea on their own behavior towards sustainability compared with the outside environment. Intermodal transport plays no role in the considerations at the predominating part of the LSP (77%). Of course this answer could be the result of the restrictions of the domain the respondents are working in. This aspect will have to be investigated thoroughly later on in the survey – we need to have more answers. When the respondents indicate the possibility of intermodal transport, they indicate this will be stipulated by customer requirements as punctuality, small volumes etc. (46%). It appears that intermodal transport has only a chance when LSP (with possible colleague companies) and customer jointly search for solutions and possibilities offered by intermodal transportation.

The use of models in order to support strategic decisions on sustainability
The majority of the respondents (62%) doesn´t use a DSM to improve sustainability. This group uses internal company instruments or confesses to be unfamiliar with the subject. Those who do use a DSM (38%) mention Excel calculations, planning tools, CO_2 - estimates and compare calculations and notes. When asked what kind of models would be suitable for their decisions, the majority of the companies tend to opt for models which combine mathematical calculations with personal experiences (62%). The need for pure mathematical models is low (8%). On the other hand, half of the respondents who want combined models expect these models to rely more on mathematical algorithms as on personal experiences and knowledge. A quarter wants both aspects to play an equal role.

As a preliminary conclusion it could be said that a combination of models based on hard data with models based on experience could create a good structure to build a decision process most helpful for the LSP.

USE OF DECISION SUPPORT MODELS BY LOGISTIC SERVICE PROVIDERS

When asked if they used a DSM for sustainable decisions a minority (38%) answered yes. The reason why the rest did not use a DSM seems to be a lack of knowledge of DSM's in general. This may be due to the character of DSM's, or due to the knowledge or attitude of logistic managers. It seems logical that decision makers would like to have one overall DSM to aid them with the various decisions on all levels of decision making. But the use of one DSM for all three levels simultaneously will be confronted with the following aspects:

- a DSM comes in three variations: 1) qualitative or heuristic, 2) mathematical and 3) mixed (Palmer 2007);
- these DSMs support physical transport decision on operational, tactical and strategic level (Schneeweiss 2003);
- the decision makers on transportation are rarely faced with strategic issues (Weijers, Glöckner & Pieters 2007) and
- a DSM on a strategic level will include less detailed aspects as compared to a model used at a tactical and on an operational level (Tipi 2009).

These facts will impact the appreciation of a strategic DSM by the logistics manager, as, supposedly, he would be inclined to use this DSM not as much for strategic use, but for short and middle term goals as well. Another aspect when considering sustainability is that reduction of greenhouse gasses is the main focus for a LSP. It should therefore not come as a surprise that most of these DSMs concentrate on this aspect (Nagurney 2000; Van der Vorst 2000; Palmer 2007; Venigalla 2008) or try to determine the external costs

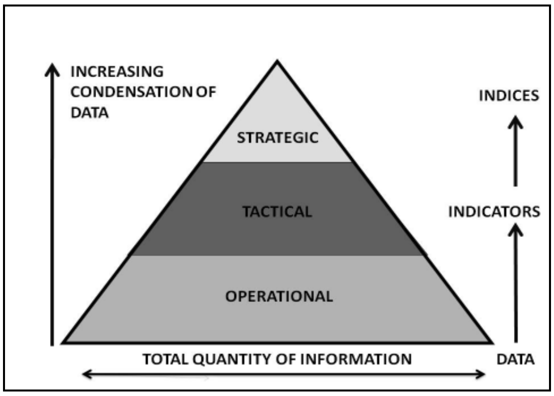

Figure 6 Relationship between indicators, data, information and level

(Maibach 2008; Delucchi 2008) and therefore tend to be mathematical. In order to understand the situation as mentioned above, we have adapted the model of Bell and Morse and build a model as shown in figure 1. It shows that a DSM used for strategic purposes will generate indices on which companies develop their strategy for the future. On a tactical level the DSM should produce indicators and for operational decisions as many indicators as are needed. Combined with Ashby's Law (1958) which states that the variety in a DSM must be equal to or larger than the variety of the perturbations which the DSM wants to control, we may expect an explosion of variables for the operational level. A DSM for operational sustainable transportation aspects will have to include more variables as a DSM for strategic sustainable transportation issues. This will result in a DSM which is difficult to maintain as the data needs to be updated on a regular basis in order to assure that the user will have the latest reliable information. If this updating of variables required to make the DSM suitable for an operational level, has to be done by the user and will take up much of his time, the updating of this information will be less frequent and the accuracy of the outcome and consequently the trust of the user in the DSM will fall with as a result that the DSM will not be used anymore. Beside this point, by making the DSM fit for a huge number of variables, the relationship between inputs and results will become unclear and less understandable for the user who could lose faith in the model.

CONCLUSIONS FOR STRUCTURING DECISION SUPPORT MODELS

Taking these considerations into account, we think that a DSM in order to become suitable for a sustainable transportation strategy, requires not be difficult to maintain, and therefore requires to rely on a limited database, suitable just for the required task. For any organization, applying an overall DSM which deals with all aspects of sustainability and transport for this organization will therefore not be a good idea. Such a DSM will require too much data and maintenance and be difficult to manage. In our opinion, an organization should use a structure of DSMs, all dealing with sustainability, on different levels. An individual DSM would target only one or two levels as shown in figure 2.

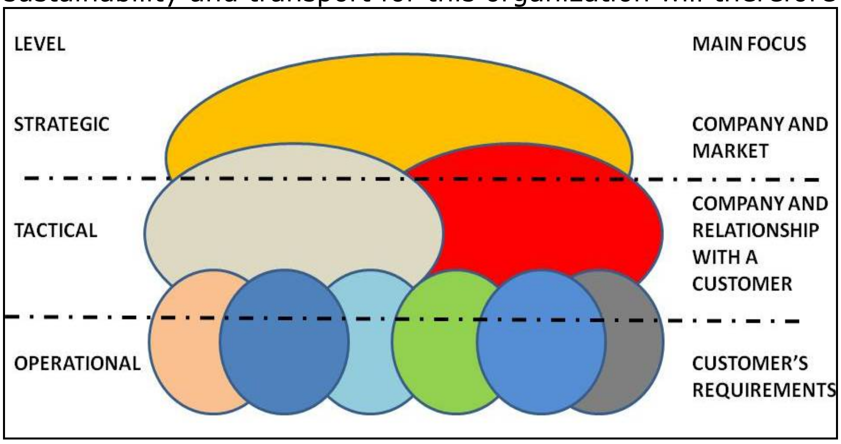

Figure 7 Level of employment of DSMs within an organization

Considering Palmer's division of models (2007) we suggest using:

1. The qualitative or heuristic models for setting up the overall company´s strategy and its relationship with the market;
2. Models which are a mix of heuristic and mathematical aspects to determine the internal structure of the company and the relationship with important customers and
3. Mathematical models for decisions focussing on individual or groups of customers.

The various models do not have to be interrelated horizontally directly, but should fit vertically in order not to create a breach with the company´s strategy. They can be build on a modular basis and suit the requirements for this specific situation. By focusing more on the intended user, the chance of a DSM to be actually used will increase as it focuses on the specific needs of this individual user or user group. By serving with one DSM the specific and not often coinciding needs of many users, the higher the danger that a DSM will fit all user´s needs but will be used by none.

At present, due to the lack of a representative response, it is impossible to indicate whether our three hypotheses are refuted or accepted. The outcome of the outstanding survey will be used for further research and should result in an advice to builders and users of these DSM in order to save time and money and to improve the sustainability of transportation.

REFERENCES

Ashby, W.R., (1958) Requisite Variety and its implications for the control of complex systems *Cybernetica* (Namur) Vo1 1, No 2,

Bell, S., & Morse, S. (2003). *Measuring sustainability. Learning from doing*. London: Earthscan

Braat, L. (1991). "The predictive meaning of sustainability indicators". In O. Kuik, & H. Verbruggen (Eds.), *In search of indicators of sustainable development* (pp. 57–70). Dordrecht: Kluwer Academic Publishers.

Delucchi, M.M., (2008) The Social Cost of Motor vehicle Use in the United States, in M. Kutz (Ed.) *Environmental Conscious Transportation* John Wiley & Sons, Hoboken N.J., USA

European Commission(2004) *European Energy and Transport Scenarios on key Drivers* Luxemburg

Macharis. C., (2007) "Intermodaal vervoersbeleid in België en Nederland" *Logistiek.nl* 5 apr 2007

Maibach, M., C. Schreyer, D. Sutter, H.P. van Essen, B.H. Boon, R. Smokers, A. Schroten, C. Doll, B. Pawlowska and M. Bak (2008) *Handbook on estimation of external cost in the transport sector* Delft

McDonough, W., and M. Braungart, (2002) *Cradle to Cradle: Remaking the Way we Make Things*. New York: North Point Press.

Nagurney, Anna (2000) *Sustainable Transportation Networks* Edward Elgar Cheltenham UK/Northampton USA

Palmer, A., (2007) *The Development of an Integrated Routing and Carbon Dioxide Emissions Model for Goods Vehicles* Cranfield University

Pezzey, J. C. V. , (2007) Sustainability Constraints versus "Optimality" versus Intertemporal Concern, and Axioms versus Data *Land Economics*, Vol. 73, No. 4, (1997), Defining Sustainability (Nov., 1997), pp. 448-466

Pieters, R. and K. Herder, (2009) Transportation and Sustainability: a Difficult Match, in George M. Papadourakis and Ionannis Lazaridis (Ed): *Proceedings of the 6th international conference on New Horizons in Industry and Education (NHIBE).* p 557-562, Santorini 2009.

Pieters, R., E. Koekebakker, N. Lamers, A. Stelling G. Vos en S., Weijers, Instrumenten Voor Vernieuwing Van Europese Goederentransportnetwerken in: *Vervoerslogistieke Werkdagen 2009*, Deurne, 12-13 november 2009.

Pieters, R., H. H. Glöckner and S. J. C. M. Weijers, (2009) Sustainability in Logistics Practice, in *Proceedings of the 14th International Symposium On Logistics*, Istanbul

Ploos van Amstel, W., (2008) *Logistiek* Pearson, Amsterdam,

Porter, M. E., & Kramer, M. R. (2004). Strategy and society: The link between competitive advantage and corporate social responsibility. Harvard Business Review, 84(12), 5–12.

Ron, A. de., (2001) *Duurzaam ondernemen: een inleiding* Kluwer, Deventer

Schneeweiss, C., (2003) Distributed decision making in supply chain management *European Journal of Operational Research* Volume 150, Issue 2, 16 October 2003, Pages

237-252
Tipi, N.S., (2009) Modeling Performance Measures for Supply Chain Systems using Discrete Event Simulation, in *Proceedings of the 14th International Symposium On Logistics*, Istanbul
Venigalla, M.M., (2008) Transportation and Air Quality, in M. Kutz (Ed.) *Environmental Conscious Transportation* John Wiley & Sons, Hoboken N.J., USA
Vorst, van der J.G.A.J., (2000) *Effective Food Supply Chains: generating, modeling and evaluating supply chain scenarios* Dissertation WUR Wageningen
Weijers S., R. Pieters, L. Peeters, D. Piets and E. Vooren, (2007), Digiscan: a tool to find made-to-measure solutions for improving efficiencies in transportation, in Szakál A. (ed), *Proceedings LINDI 2007*. Wildau p 174-179.

UTILISATION-BASED MAINTENANCE OF INTRALOGISTICS-SYSTEMS

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ABSTRACT
In modern times, far-reaching changes especially in production have taken place. Lean manufacturing systems require delivery strategies such as just-in-time or just-in-sequence that are synchronised with production demand to make sure the optimal amount of inventory is on hand at any time. This development comes along with both increasing dependence and cross-linking of in-house-logistics systems, also called intralogistics-systems, that raises sharply the probability of negative impacts of unplanned breakdowns. Against this background the importance of maintenance for intralogistics-systems increases. But instead of intelligent maintenance concepts, the intralogistics industry faces this challenge by providing robust and oversized systems.

Therefore, the Chair of Factory Organisation in cooperation with the Fraunhofer Institute for Material Flow and Logistics (IML) approach the problem of construction and maintenance of intralogistics-systems in order to find different, more efficient ways to reliability and availability.

Keywords:
Logistics systems, Maintenance, Condition Monitoring

INTRODUCTION
Nowadays, logistics represent an important factor in terms of competitiveness and economy for manufacturing companies as well as commercial enterprises. This manly lies in the dynamic market development caused, among others, by globalisation.
Those changes result in extremely high levelled requirements towards logistics. Several industries are reducing downtime and buffer stock to zero. Therefore, complex delivery strategies such as just-in-time and just-in-sequence require one hundred percent efficient supply-chains [1]. The rule of a chain being as strong as its weakest link can be transferred to supply-chains. Consequently, the requirements concerning reliability and availability of each link increase, because logistics-services cannot be produced to stock [2]. This applies to production facilities and particularly to their intralogistics-systems, which ensure the in-house flow of material and information. Experts agree on intralogistics being the crucial element of a successful supply chain and its bottleneck at the same time [3]. The whole supply chain and the supplied industries depend on the performance of intralogistics. Unscheduled down-times and failures of the intralogistics-systems have to be avoided in order to provide a continuous and accurate material flow, which is an indispensable requirement for organisational success. Therefore, intralogistics-systems have to be reliable [2]. In practice, this required reliability is provided through oversizing and redundancies of systems and components.

INTRALOGISTICS-SYSTEMS – A DISAMBIGUATION
The term logistics has a wide range and is often believed to merely refer to transportation of goods from point A to point B. But the main potential for cost reduction and innovation is within the in-house sector of organisational logistics, the intralogistics sector [1]. According to the common definition, intralogistics include the organisation, control, execution and optimisation of the in-house material flow as well as stock turnover in industry, trade and public institutions [3]. This definition reveals the technical, economical and social importance of intralogistics. They are an important factor in different organisations of various sizes, such as factories, distribution centres, harbours, airports, supermarkets, hospitals, etc.. This definition distinguishes

intralogistics from other logistical fields such as transportation logistics, which connect different organisations, and supply chain management, that is responsible for chains in procurement and sales as well as optimisation of locations and inventory. Intralogistics help supplying material and information as required and ensures production of high quality products at the right time, without excessive waste and inventory buffer. Industrial production has changed immensely within recent years. Along with the developments of just-in-time and just-in-sequence deliveries, intralogistics have become one of the biggest engineering sector in Germany.

The intralogistics industry is constantly working on designing innovative solutions in order to be more cost-efficient [4]. One challenge that the industry has to face is that their product, intralogistics services, cannot be produced to stock [2]. Therefore, they have to provide a high ratio of availability of the systems and the best quality possible for their logistics services. Otherwise, a breakdown or failure usually entails high follow-up costs. This background explains the great significance of maintenance of intralogistics-systems. High availability and performance that meets expectations can be achieved by applying adequate maintenance actions [5, 6, 7]. Nonetheless, customers demand reliable facilities at low investment costs but with long warranty periods. They demand equipment that does not or only rarely require maintenance, although it should be clear that this is impossible to realise. Intralogistics is an important economic and competitive factor. It ensures production in modern production systems and they are an important export product in Germany. To make sure that it stays that way, measures have to be taken to increase reliability. And those measures have to be affordable. An elaborate maintenance concept could be a solution to this task.

DESIGN AND OPERATION OF INTRALOGISTICS MATERIAL FLOW SYSTEMS

The intralogistics-industry tries to meet customer demands by providing robust equipment and systems in order to achieve high availability and reliability. The basis for this strategy is already laid during the planning phase for an intralogistics-system. There are a lot of tools and techniques for planning the intralogistics-systems, but they are inexact, due to existing planning-uncertainties [8]. One uncertainty is the expected peak power of a 10-years-planning horizon. It is used as a basis to anticipate a future capacity-addition [9, 10]. In this context, it is important that reserved backup power is high enough to avoid the need for short- or medium-term addition to capacity. Neither should the backup power be excessive, because it would create extra costs [10]. However, robust construction is not the only planning principle. In addition to a robust construction, redundancies are implemented to minimise negative consequences of unscheduled failures and downtimes [11].

Systems are usually realised with standard components that have been time-tested and approved. These standard components also help realising short completion times that are demanded by customers [9]. The manufacturer is responsible for the accuracy of the system and the operation-time of the equipment. Thus, dimensioning of the units and the reliability of the system lies within his range of responsibility [12]. Calculation programs should help predict the availability of a system as accurately as possible. But it is just as important to maintain this availability throughout the time of operation over several years or even decades. The fulfilment of those requirements is a task of maintenance [7, 9]. Experience shows that accurately timed maintenance actions and custom-fit modernisation in adequate intervals can ensure availability and performance of intralogistics-systems that meet customer requirements in a cost-effective way [12]. Intelligent concepts of maintenance should be able to detect the condition of elements and components and predict their remaining life. If this were possible, it would contribute to increasing reliability of intralogistics-systems and reducing follow-up costs. The Chair of Factory Organisation in cooperation with the Fraunhofer IML research in this field to develop tools and concepts for maintenance of intralogistics-systems to increase their availability and reliability.

MAINTENANCE OF INTRALOGISTICS-SYSTEMS

Within the research project "SFB 696"[1] at the Technical University in Dortmund a field study about maintenance of intralogistics-systems has been carried out by the sub-project C3. The field study has been conducted among manufacturers and operators to gain knowledge about maintenance of intralogistics-systems. The results were discussed and verified during a workshop with experts from the intralogistics industry. The most important result is that a considerable waste of resources is accepted during planning and operation of intralogistics-systems.

One waste of resources is the reserved backup power. This backup power is usually higher than realistically needed, because the operator cannot predict the future workload for ten years in advance. Therefore, he deliberately uses a higher amount as a basis for the construction of the system in order to avoid the necessity of a short-term expansion of capacity. As a result, the system is designed for a longer lifetime, so that there is no need for short- or medium-term modernisations to increase performance. An intralogistics-system is always a custom-designed solution but it is realised with standard components. These standard components are not designed to match the actual demand. As a consequence of oversizing, components, e.g. electric powertrains, are not working to capacity and do not reach their nominal efficiency [13]. A further consequence is a higher wear-out of mechanical components, whereas reliability and availability do not increase with oversized components [14, 15].

The resulting robustness is intended by manufacturers, to avoid breakdowns during the warranty period, which can last up to five years. Robustness is also regarded as a manufacturer's quality characteristic. Nonetheless, this design usually results in higher operating costs for the operator in the long term.

Despite the great importance of availability and reliability, the topic of maintenance of those systems has not been in the focus of attention for a long time. In production systems, maintenance has a high priority and modern techniques and tools such as condition monitoring systems are applied [6]. In contrast to that, maintenance of logistics components and systems is usually carried out breakdown- or time-based [2, 12]. This seems surprising considering how important their availability is and how much effort the manufacturer puts into providing it. However, it is not possible to completely prevent breakdowns. Consequences of a breakdown are fatal, because it can result in follow-up costs of unscheduled downtime that can be up to four times higher than maintenance costs [16]. Besides, time-based maintenance also results in a waste of resources, because components are never used long enough to reach their maximum utilisation. How long a component could have been used instead of replacing it is usually not analysed. Therefore, adjusting the intervals for time-based maintenance according to the wear-out of components is not possible.

A solution could be to adjust the maintenance strategy according to the actual utilisation of components. It would help overcome the problems which occur as a result of the current methods. Nevertheless, a maintenance strategy that involves the actual utilisation and thus saves resources is hard to apply, because neither operators nor manufacturers possess the knowledge in necessary width and depth. Hardly any knowledge exists about the interrelation between utilisation and wear-out of intralogistics-systems. Although the loads of intralogistics-systems, such as the weight of a loading unit, are recorded by IT-systems, they are not analysed and used for maintenance purposes. Knowledge about the actual utilisation is insufficient, which results in a lack of experience for the maintenance of intralogistics-systems. This is not only due to the practice of oversizing. But often the contact between manufacturer and operator ends with the warranty period for the system. Only lately, a demand for after

[1] Sonderforschungsbereich 696 – Forderungsgerechte Auslegung von Intralogistiksystemen – Logistics on Demand

sales services has begun to develop. In the future, this will change significantly and manufacturers will shift from sales to full-service-concepts and a holistic approach to intralogistics-systems. Another obstacle when realising a concept of utilisation-based maintenance is the lack of documentation and information [17]. Although technicians keep records of their performed maintenance actions, they do not keep track of the causes for the problems that have occurred. Therefore, drawing conclusions about the failure causes and the actual load on components is not possible [6]. Manufacturers have lately begun acquiring knowledge and experience in this field, due to the growing significance of intralogistics and the associated costs. Service contracts, even lifetime partnerships, lead to savings and a win-win-situation for both operator and manufacturer. The manufacturer improves his customer orientation and the operator increases the reliability and availability of the system.

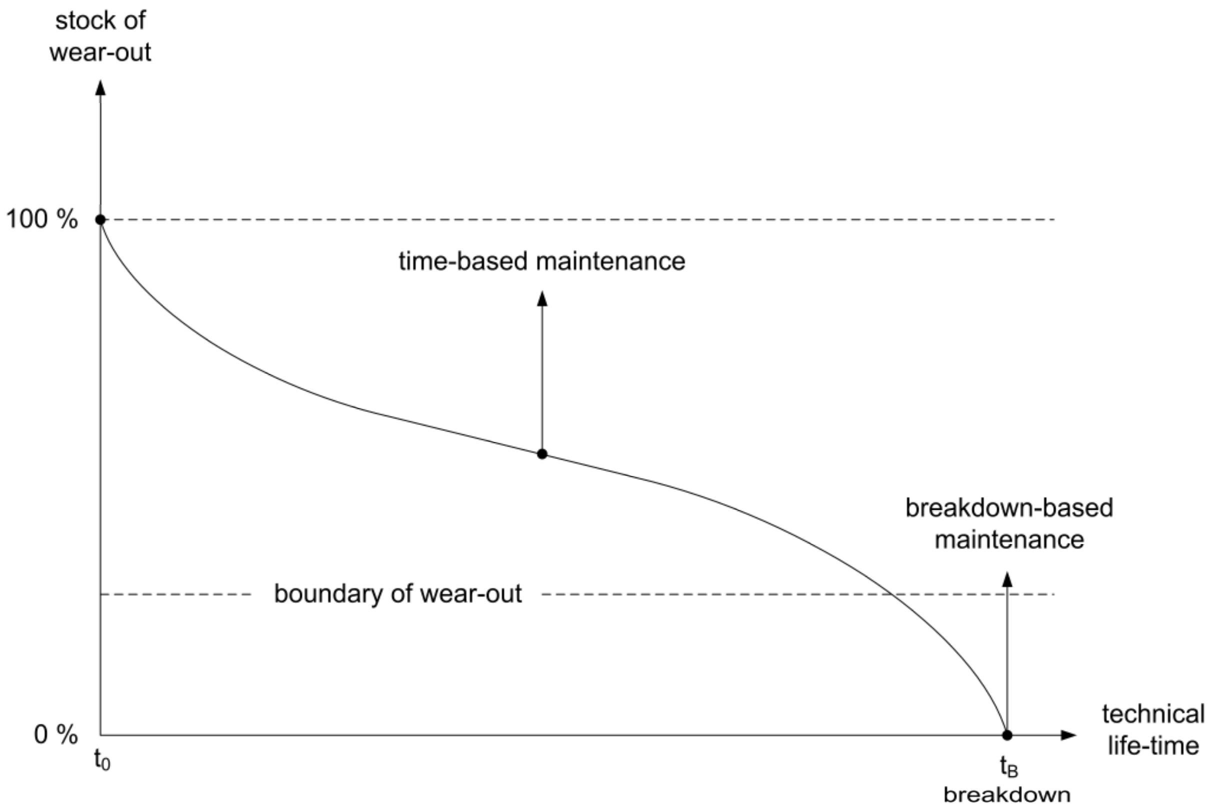

Figure 8 - Arguments for an utilisation-based maintenance

In summary, it can be stated that there is a huge need for optimisation in planning, regarding robustness of the systems, as well as in operating intralogistics-systems, in terms of the practiced maintenance strategy. In the following, a new approach to the maintenance of intralogistics systems will be introduced.

UTILISATION-BASED MAINTENANCE

An utilisation-based maintenance monitors the actual condition of a component and the development of the stock of wear-out by considering its underlying individual utilisation profile. Hence, the component will be replaced only, when a determined level of wear-out is undercut. This comes with the advantage of a maximum utilisation of stock of wear-out as well as the avoidance of unscheduled downtimes, thus, it is the most efficient way of maintenance. However, to monitor the condition of a unit at regular intervals has the disadvantage of considering just the actual condition. It would make more sense to acquire and process those data continuously in order to recognise the long-term development of wear-out and to predict the achievement of critical limiting values. Therefore, it is necessary to gather real-time data during the time of operation to better predict the dynamic changing utilisation profile of an intralogistics-system in order to extrapolate the resulting impact on the development of wear-out of its components [18, 19].

The huge backlog in maintenance especially the interrelation between utilisation and wear-out of intralogistics-systems caused the installation of the "Logistics Condition Monitoring-Technology Laboratory" (Log CoMo-Tec Lab).

LOGISTICS CONDITION MONITORING TECHNOLOGIES LABORATORY

The Log CoMo-Tec Lab was established by the Chair of Factory Organisation at the TU Dortmund in cooperation with the Fraunhofer Institute for Material Flow and Logistics. The Fraunhofer-Gesellschaft realised the enormous research potential in this field and accepted the total acquisition costs. In the Log CoMo-Tec Lab the interrelation between utilisation and wear-out of components of intralogistics-systems will be researched sui generis by the use of condition monitoring technologies.

Condition Monitoring is the targeted monitoring of components concerning critical trends as well as the forecast of the time of failure [20]. Condition Monitoring is also the basis for a condition-based maintenance. The monitoring of the condition of components can be carried out by different techniques, e.g. vibration diagnosis, torque measurement, lubrication analysis or thermography. The use of condition monitoring pursues the goal decrease downtimes to and increase availability [7]. Further it contributes to optimised energy efficiency, because the efficiency of components is checked continuously [21].

The Log CoMo-Tec Lab consists of different typical intralogistics-subsystems: One automated guided vehicle system, roll conveyors and a miniload automated storage and retrieval system (ASRS).

Figure 9 - Logistics Condition Monitoring Technologies Laboratory

In the Log CoMo-Tec Lab three different techniques are used for the monitoring of components: Vibration analysis at all drives of the roll conveyor and at the automated guided vehicle, torque measurement at the drive of the lift of the ASRS and a thermography camera.

With the assistance of these Condition Monitoring techniques, information about thermal and dynamic effects will be obtained and evaluated in the intralogistics-system. As an example, the figure 3 illustrates different results emerged from vibration analysis of two different drives of the roll conveyor. The upper diagram without any periodical vibrations belongs to a drive of the intralogistics-system. In contrast to that, the lower diagram belonging to another drive is characterised by periodical peaks indicating the damage frequency of the anti-friction bearing implemented in the drive motor. Hence, an upcoming failure can be perceived early enough to act contrary to an unplanned breakdown.

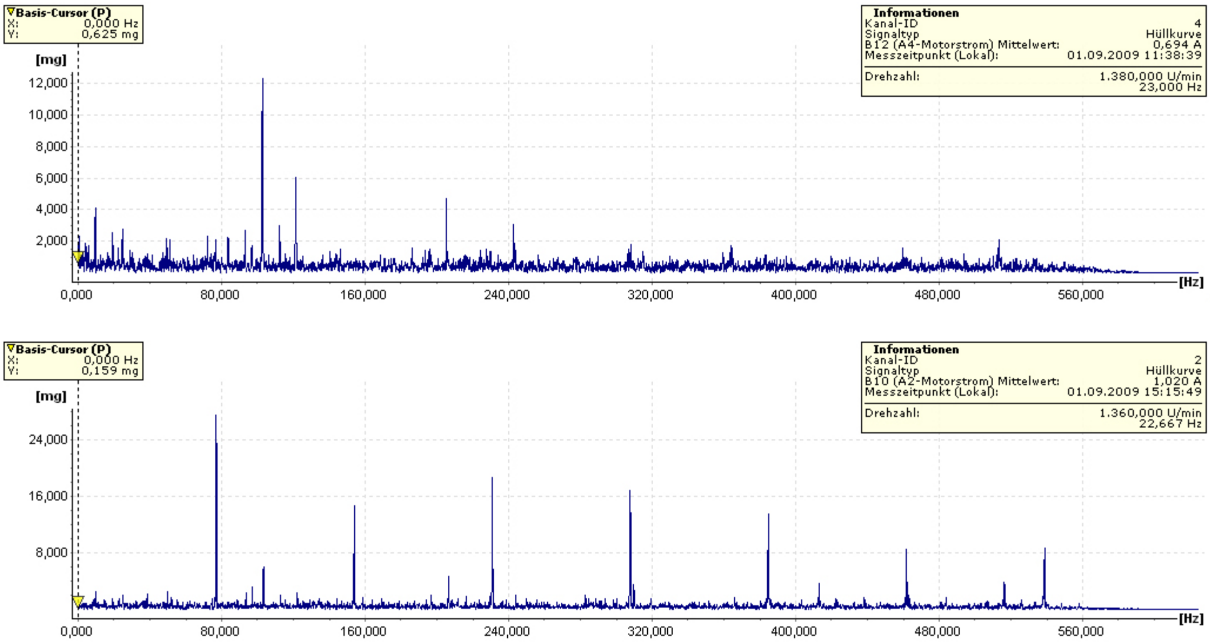

Figure 10 - Vibration analysis of roll conveyor drives

An expected result will be the knowledge about the interrelation between utilisation and wear-out of components in an intralogistics-system. With the knowledge about the interrelation between utilisation and wear-out it is possible, inter alia, to implement utilisation-based maintenance in intralogistics-systems.

CONCLUSION

The basic task of intralogistics is making processes more efficient, planning capacities and performance and using them in a better way. For this reason it contributes to environmental protection and improved profitability and competitiveness of organisations.

Unpredictable market developments can thwart any planning. In addition, robust intralogistics-systems query optimal modernisation intervals. Availability could be also achieved with adequate maintenance techniques and actions instead of costly redundancies and oversizing. Maintenance actions could be carried out conserving large amounts of resources and unscheduled downtimes could be reduced, while requirement-based components would help save energy. Furthermore, modernisations at the right time bear the potential to generate large savings in terms of needed optimisation [23]. Due to fast changes in technical areas as well as in costs for resources such as steel and energy, it might be reasonable to shift from robust construction of intralogistics-systems to intelligent maintenance concepts in order to insure the demanded reliability.

There is still a high potential in the planning and operating of intralogistics-systems with regards to their efficiency. The Chair of Factory Organisation and the Fraunhofer IML accept this challenge. The Log CoMo-Tec Lab is an adequate reference system for further research activities.

REFERENCES

[1] Miebach, J., Müller, P., 2006, Intralogistik als wichtigstes Glied von umfassenden Lieferketten, In: Arnold, D. (ed.), Intralogistik – Potentiale, Perspektiven, Prognosen, Springer, Berlin, Heidelberg 20-31.

[2] Weißenbach, A., 2007, Ein Instandhaltungsnetzwerk für Logistiksysteme, Modernisierungsfibel, 10-11.

[3] Arnold, D., 2006, Intralogistik – Potentiale, Perspektiven, Prognosen, Springer, Berlin, Heidelberg 1-4.

[4] Hahn-Wörnle, C., 2008, Statement 6th press conference at „Forum Intralogistik". Frankfurt am Main, Germany.

[5] Dhillon, B.: Engineering Maintenance. CRC Press LCC, Boca Raton, USA, 2002.

[6] Schuh, G., Winter, C.-P., Lorenz, B., Burgwinkel, P., Lachmann, J., 2008, Integration von Echtzeitsimulation und Zustandsüberwachung zur Bauteilzustandprognose und Fehleranalyse für die Instandhaltung, Proceedings of the 7th AKIDA, Aachen, 181-188.

[7] Matyas, K., 2008, Taschenbuch Instandhaltungslogistik, Carl Hanser Verlag, Munich.

[8] Meinhardt, I., Marquardt, H.-G., 2007, Offenes Baukastensystem zur effizienten Dimensionierung von Materialflusssystemen, Logistics Journal, 1-14.

[9] Scheid, W.-M., 2007, Modernisierung von Logistik-Anlagen, Modernisierungsfibel, 6-8.

[10] Dullinger, K.-H., 2008, Grenzen der Automatisierung im Lager, Logistik für Unternehmen, 05/06, 61-52.

[11] Wenzel, S., Bandow, G. 2009, Oversizing Or Maintenance - Two Ways For Reliable Intralogistics-Systems. In: Proceedings of 14th Annual International Conference on Industrial Engineering - Theory, Applications & Practice, 18.-21.10.2009, Anaheim, USA, 142-146,

[12] Dullinger, K.-H., 2008, Quo Vadis – Material Handling, vol. 2. Vanderlande Industries, Mönchengladbach.

[13] Streibel, M., 2009, Energieeffizienz – Herausforderung für die Industrie, Proceedings of the 13th InstandhaltungsForum, Dortmund, 13-24.

[14] Kandziora, M., 2002, Die Mechanik wird's danken, In: IEE Elektrische Automatisierung + Antriebstechnik, Book 8, Hüthig GmbH, Heidelberg, 62

[15] Kupp, St., 2008, Richtige Dimensionierung führt zu erhöhter Energieeffizienz, URL www.innovations-report.de, visit: 10.06.2008

[16] Kuhn, A., Schuh, G., Stahl, B. (ed.), Bandow, G., Franzkoch, B., Kampker, A., Wemhöner, N., 2006, Nachhaltige Instandhaltung – Trends, Potenziale und Handlungsfelder Nachhaltiger Instandhaltung. VDMA Verlag, Frankfurt am Main, Germany.

[17] Schuh, G., Klimek, G., 2009, Informations- und Kommunikationstechnologien für die Instandhaltungsplanung und –steuerung, In: Reichel, J., Mandelartz, J., Müller, G. (ed.), Betriebliche Instandhaltung, Springer Verlag, Berlin, 151-161.

[18] Wenzel, S., Köpcke, C., Bandow, G. (2010): Reliability of Intralogistics-Systems - Oversizing or Maintenance. In: Proceedings of the 4th CIRP International Conference on Competitive Manufacturing, 03.-05.02.2010, Stellenbosch, South Africa, S. 383-388

[19] Sonderforschungsbereich 696 – Anforderungsgerechte Auslegung von intralogistischen Systemen – Logistics on Demand, 2010, Interim Report, Sub-project C3.

[20] Albrecht, V., Wetzel, P., 2008, M-TCO – Daimler AG, In: Lebenszykloskosten optimieren - Paradigmenwechsel für Anbieter und Nutzer von Investitionsgütern, Gabler, Wiesbaden, 81-95

[21] Poll, Dietmar, 2009, Effizienz-Steigerung kein Modetrend – Condition Monitoring, In: Produktion – Die Zeitschrift für die deutsche Industrie, 06/2009, Verlag Moderne Industrie.

[22] Denkena B., Radons, G., Blümel, P., 2006, Verfügbarkeitspotentiale vollständig ausschöpfen: Einsatz von Verschleiß- und Störungsprognose zur voraussagenden Instandhaltung, In: wt Werkstattstechnik online, Springer-VDI-Verlag, Düsseldorf, Ausgabe 7/8-2006, 548-554.

[23] Figgener, O., 2006, Standards für die Logistik, In: Software in der Logistik – Marktspiegel, Hussverlag, München, 26-29.

IDENTIFYING TRENDS IN THE ADOPTION OF ICT IN PORTS TO ENABLE INFORMATION VISIBILITY IN LOGISTICS INVOLVING ROAD HAULAGE

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ABSTRACT. Port terminals have become a prime example of complex logistics fully dependent on Information and Communication Technology (ICT) and in recent years, container terminals have been at the forefront of adopting sophisticated ICT solutions. On the other hand, the adoption of ICT for enabling visibility in road haulage operations serving in ports offers several challenges. A multiple case study involving five container terminals in two continents is used to investigate trends in the adoption of ICT **used to link road hauliers with logistics operations**, namely planning, execution and vehicular communication capabilities. The multiple case also identifies elements **of institutional isomorphism to generate a concept model based on** obstacles and challenges associated to the adoption of ICT related to interoperability and connectivity in multimodal logistics involving sea transportation and road haulage.

PURPOSE. The purpose of the paper is to expand the current knowledge available on the trends dictating the adoption of ICT in container terminals at a time where haulage operations play a key role in the overall efficiency of such premises.

INTRODUCTION

Information and Communication Technology (ICT) is central to economic activities and logistics is no exception to that. Complex logistics arrangements can result from the combination of different modes of transportation like road, sea and air. In particular port operations comprise complex arrangements in where road transportation plays a key role. In this scenario ports can benefit from ICT developments because many of them suffer from congestion and are in urgent need of procedures and technologies to increase the through-put speed of goods (Nyquist, 2009). The sort of operations taking place in ports confirm the observations made by Lai et al. (2008) about logistics activities being inter-dependent, requiring careful allocation of resources to achieve service goals and to reduce wastes in the supply chain such as idle time, and duplication of efforts. Complexity in ports is also due to the various types of cargoes handled such as containers, bulks (solids and liquids), ro-ro, lo-lo, heavy-lift and out-of-gauge cargoes.

In transport logistics the application of ICT is to facilitate activities such as cargo tracking, warehousing, and shipment notice forwarding, in support of product movement in the supply chain (Wong et al., 2009). The diversity of logistics activities found in ports and the various types of technologies available represent a formidable challenge in terms of identifying trends dictating the adoption of ICT. As a consequence there have been significant efforts at generating recommendations that can facilitate inter-operability and connectivity in multimodal logistics. Examples include the EU Commission launching initiatives to develop a pan-European maritime information infrastructure in order to reduce reporting activities between a vessel and different authorities and commercial entities (Ekelof, 2009) or the UN/CEFACT (2010) recommendations on codes for mode of transport.

On the adoption of various technologies based on radio signals, RFID tags have been widely used to track and trace different types of cargoes within the confinement of a port area. The RFID tag may be attached directly to the cargo or carried by the driver/operator of a haulage vehicle serving in the port premises. Technologies broadly used to link haulage vehicles include cellular networks and satellite systems and in a lesser scale Wi-Fi, UMTS, 4G and WiMax. Nonetheless, significant challenges still persist in terms of reliability and connectivity, problems due to difficulties associated with limited range, scalability and security (Mondragon et al., 2009).

Many factors can influence the adoption of ICT in port facilities. For example, regarding the adoption of technology for the security enhancement of container transport, Lun et al. (2008) explored the implications of the different types of institutional isomorphisms including coercion, mimesis and norms, from both the perspectives of organisations that have taken the initiative to adopt technology for container transport security enhancement and those that have followed early adopters.

This paper investigates trends in the adoption of ICT with the purpose of linking road hauliers with the port terminal logistics operations, namely planning, execution and vehicular communication capabilities of ICT. Then using elements of institutional isomorphism the paper looks at generating a concept model based on expanding on obstacles and challenges associated with setting and defining ICT standards to enable interoperability and connectivity in multimodal logistics. The multiple case research is the methodology employed in this paper.

LITERATURE REVIEW

Representative studies in the field of ICT adoption in logistics and supply chain management have covered the development of models to examine the relationships among perceived benefits, perceived barriers and organisational context related to the adoption of information systems in logistics companies in a given region (Ngai et al., 2008). This is important as in a port terminal, there can be numerous ICT applications being used at the same time. Stahlbock R and Voß (2008) acknowledge that powerful ICT and logistics control software systems including optimisation methods can be deployed so existing infrastructure and equipment can be used more efficiently.

The recognition by Hidalgo and Lopez (2009) that the availability of high-quality transport and logistics services (TLS) is of paramount importance for the growth and competitiveness of an economy lead them to describe how European companies in this sector use ICT for conducting business and to assess the impact of this development for firms and the industry as a whole. The use of the structure-conduct-performance (SCP) model and the bi-directional relationships of its elements, enabled the authors to identify the links between ICT adoption and market structure, innovation dynamics, and firm performance.

Major port logistics operations depend on the use of road haulage. Research work on the use of ICT in road haulage carried out by Davies et al. (2007) highlight benefits such as reduced transaction and administration costs and for road hauliers the opportunity to offer excess capacity to a greater client base and the possibility to maximise loaded miles leading to a reduction of freight charges. For clients ICT gives the opportunity to increase the number of road hauliers they can reach. Eventually, the increase in competition and improved utilisation of a road hauliers' fleet may result in reduced charges.

On the use of ICT, in particular control software in container terminals, Günther and Kim (2006) highlight that logistics control in large-sized container terminals is a tremendously complex task, which requires real-time decisions on matching handling tasks with the corresponding equipment units and the provision of detailed information about each individual container. The authors clearly state that different modes of software and IT support as well as use of sophisticated optimisation tools are issues of considerable importance.

In recent times vendors of sophisticated ICT systems may have become a source of influence in the adoption of ICT in port terminals. For example, those selling terminal operating solutions claim that the use of their products can result on significant reductions in administrative, support and operating costs, improve yard utilisation and stacking yard capacity, optimisation of vessel planning and increasing flexibility and business intelligence. The complexity related to the adoption of ICT in port operations can be linked to what McAffee (2006) identifies as the responsibilities faced by executives such as: help to choose technologies, use an inside-out approach that keeps the true needs of the business in mind; smooth the adoption of those technologies, take into account the encounter of strong resistance; and encourage exploitation by leveraging already standardised data and work flows.

An important concept that has been acknowledged lately is Lai's et al. (2006) recognition that organisations in a supply chain often adopt ICT due to the institutional pressure exerted by their supply chain partners. A port terminal is a scenario that offers the possibility to investigate such issues. According to Lai et al. (2006) the implications of the three types of institutional isomorphism including coercion, mimesis, and norms, state that coercive pressures are exerted on a dependent firm by other organisations. The authors highlight that mimesis happens when a firm has ambiguous goals and operates in a volatile environment and it models itself on other organisations. According to the authors, normative processes happen where firms in the supply chain are subject to the norms, standards, and expectations of their SCM in order to attain effective coordination. Figure 1 encompasses the concepts related to ICT adoption in ports to enable information visibility in road haulage investigated in this paper.

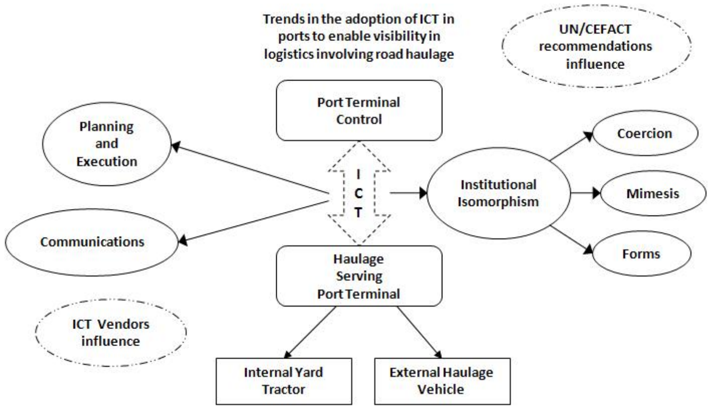

Figure 1. Concepts on ICT adoption in ports being investigated

DESCRIPTION OF THE CHALLENGE INVESTIGATED

ICT adoption in port terminals is an extensive field, hence this research work addresses elements of institutional isomorphism and ICT capabilities for planning, execution and communications to generate a concept model to facilitate a better understanding of the obstacles and challenges associated to ICT adoption and setting and defining ICT standards related to interoperability and connectivity in multimodal logistics involving sea transportation and road haulage.

THE RESEARCH WORK

The case study methodology approach has been adopted in this research work. Buganza et al. (2009) state that the case study methodology approach allows a holistic and contextualized analysis and it is properly suited for the initial phases of the exploratory nature of research work.

RESULTS/ANALYSIS

In this research it was considered important to survey the latest ICT developments that have taken place in some of the most important port facilities around the world. Hence, case studies in the form of site visits to port facilities in the Humber Estuary UK, Zeebrugge Belgium, Busan South Korea, Hong Kong and Shanghai, China were used in this work. Table 1 provides some details of the terminals investigated.

Terminal Characteristics	Port of Immingham - DFDS Nordic Terminals	Port of Zeebrugge – APM Terminals	Busan New Port – Hanjin Terminal	Port of Hong Kong – Kwai Tsing Container Terminal	Port of Shanghai – Zhanghuabang Terminal
Container berth length (m)	240	1300	1100	5000	784
Berth number (no.)	2	3	3	14	3
Water depth (m)	10.36	16	18	14.2	12.5
Total area (m2)	182,108	480,000	696,300	1,400,000	304,589
Stacking capacity (teu)	N.A.		68,800	90,000	21,736
Container quay cranes (no.)	N.A.	7	12	55	7
Rubber tyre gantry cranes (no.)	-	-	-	146	22
Rail mounted gantry crane	-	-	42	24	-
Straddle carriers	-	23	-	-	-

Table 1. Details of the container terminals investigated

The results of the case studies discuss the job scheduling/transport planning characteristics of the system used in each terminal investigated as well as the vehicular communications/track and trace capabilities in place.

Case 1. Humber-based Terminal Operator – DFDS Immingham
Terminal Characteristics. The Humber-based terminal operator moves freight consisting of containers and Ro-Ro. The company is a Humber-based, wholly-owned subsidiary of a multinational shipping company. The annual volume of containers moved in the site is in the order of 800,000 TEUs. The daily volume of trucks coming to the site to collect or deliver containers and trailers is 500. An important aspect of the whole operation of the terminal relates to dealing with the trucks coming into the site. Table 2 shows ICT planning and execution and vehicular communications capabilities.

ICT Planning and Execution Capabilities	***ICT Vehicular Communications Capabilities***
For container movement and scheduling the terminal uses two bespoke, web-enabled, in-house developed information systems which wholly support the use of EDI for bookings. The information systems are used to handle queries related to: drivers, delivering a trailer to a ship, trailers put in a ship and the exact location of the trailer in the ship. One of the bespoke systems is used to control container allocation in the terminal (by lane and by bay), as if it was a matrix.	For communications inside the terminal between individuals, between terminal-owned vehicles and the control room what is used is cellular networks because of the lower rates negotiated. No wireless communications and therefore exchange of information exist with external trucks coming into the terminal to collect/deliver containers/trailers. No Wi-Fi is used for communications inside the terminal. No GPS is currently in use, and a previous project on it was shelved.

Table 2. Details of ICT Planning, execution and communications capabilities – case 1

Presence of Coercion, Mimesis and Norms in Vehicular Communications. In this terminal case, the use of normative processes is reflected in the use of cellular networks which is the technology used for data interchange and coordination between vehicles and the container terminal. The cases for coercion and mimesis in this terminal were absent as cellular networks have become a ubiquitous technology used on a massive scale.

Case 2. Mainland Europe Terminal – Port of Zeebrugge APM Terminals.
Terminal Characteristics. The terminal operator is based in Zeebrugge Belgium and is dedicated to unloading containers from vessels and loading them on trucks. The company is part of a multinational shipping company. The annual volume of containers moved by the site is in the order of four million TEUs. The daily volume of trucks coming to the site to collect or deliver containers and trailers is 600. The average waiting time of a truck to get loaded is 35 minutes. See table 3 for details on ICT capabilities for case 2.

Presence of Coercion, Mimesis and Norms in Vehicular Communications. This case shows that no coercion has been exerted from the terminal operator to the road hauliers to adopt new technologies or the road hauliers mimicking the practices adopted by the terminal operator in terms of the use of ICT solutions used to interchange data between the terminal applications and straddle carriers/yard tractors. From a normative view, any adoption of technology (e.g. Wi-Fi) from external haulage vehicles is voluntarily and it will be unable to exploit the track and trace functionality currently available only to yard vehicles such as straddle carriers.

ICT Planning and Execution Capabilities	*ICT Vehicular Communications Capabilities*
The terminal uses a sophisticated state-of-the art, off-the-shelf application which optimises and prioritises job allocations. A total of 25 straddle carriers are used to move containers that are loaded on trucks coming into the terminal. The application is used to give operators instructions about the job they have to do. The application tells the operator of the straddle carrier where to go to pick a container and then the loading bay where to leave that container. Instructions to the operators of the straddle carriers are broadcasted by the system. Records of container boxes moved are kept in a database and updated every time the system issues a job about moving the position of a container within the terminal.	The site makes use of Wi-Fi, DGPS (Differential GPS) and UHF radio. DGPS is used to identify the exact location of a straddle carrier in the terminal. Instructions are sent by the job scheduling application to the operator of the straddle carrier using Wi-Fi. The Wi-Fi area covers the whole extension of the container terminal (600m by 1.3 km) and Wi-Fi antennas have less than 100 metres coverage and are 25 metres high. The system has double redundancy in case one access point (antenna) breaks down. UHF radio is used to contact operators in case a job is not completed or in case of warnings. Although DGPS and Wi-Fi are widely used in the terminal, the fact is that there are no reporting capabilities available with DGPS and there is no record of the movement of straddle carriers doing. Road haulage vehicles from outside cannot be identified through the use of ICT or wireless communications (Wi-Fi). In other words there are no reliable means available to monitor haulage vehicles entering the terminal to collect a container.

Table 3. Details of ICT Planning, execution and communications capabilities – case 2

Case 3. Busan New Port – Hanjin Terminal

Terminal Characteristics. This terminal based in South Korea is the fifth largest container port in the world with a volume performance in 2008 of 13,260,000 TEUs. The brand new port terminal represents state of the art facilities covering an area of 687,590 m^2 with a berth of 1.1 Km and water depth of 18 metres also this site has a maximum daily capacity of 68,800 TEUs. See table 4 for details on ICT capabilities for case 3.

ICT Planning and Execution Capabilities	*ICT Vehicular Communications Capabilities*
The site uses a sophisticated terminal automation system designed to support: - Vessel operations, whose tasks include container information check and location of cargo on board check. - Yard control, which comprises container information check, next location auto assignment and optimised work order receipt. - Loading of containers on trailer beds, comprising chassis alignment system for tandem and twin operation. The system controls: - Gate access which deals with container information check, pre-check issues, yard information, container damage check and container weighing scale. - Gantry Cranes used for container information check, remote control system, container weighting scale and chassis positioning. The use of radio frequency is fully widespread in the site and it is used in automatic recognition of truck passage and in the operation of gantry gates.	Internal yard tractors and external trucks are RFID-enabled. At each terminal entrance there is an installed RFID reader that detects and monitors external road trucks and internal yard trucks. The system represents the best solution for a horizontal layout. Every single vehicle in the terminal, both internal yard tractors or external trucks use a mandatory RFID-card approved for use in the national road network.

Table 4. Details of ICT planning, execution and communications capabilities – case 3

Presence of *Coercion, Mimesis and Norms in Vehicular Communications.* Multimodal operations on site are represented by internal yard tractors used to move containers within the port facilities and external trucks to move containers in and out of the port, more specifically in yard and gate operations. Gate operation relies on the use of RFID whilst the yard operation relies on the use of automated system labelled Automated Rail Mounted Gantry Crane (ARMGC). This terminal represents a unique example where coercion related to the adoption of ICT in the terminal has been dictated not by the terminal operator or the largest operator in the area but by the South Korean government. The coercion exerted by the government to adopt RFID tags has resulted in a normative process where RFID tags have been adopted by a significant number of organisations. The ICT infrastructure and platform used in this terminal reveals a policy towards maximising the benefits of initiatives launched by the government and associated to the deployment of technologies on national roads. Devices based on RFID technology already in use for electronic toll collection are used for identification purposes and their use represents several benefits in terms of costs and familiarity with the technology, for example, there are now switching costs associated to the adoption of RFID tags to operate in the port. However, the main disadvantage of a system based on RFID for track and trace purposes is its dependence on the distance separating the RFID readers, however this problem can be solved with the simultaneous use of GPS technology. External road hauliers may model themselves on the container terminal.

Case 4. Port of Hong Kong – Kwai Tsing Container Terminal

Terminal Characteristics. This port represents the third largest container port in the world with a volume in 2008 of 24 million TEUs. The main container terminal in this port is run by the largest container terminal operator in the world who has been recognised as one of the most important in terms of volumes handled, productivity and use of advanced ICT. The findings from the analysis of this terminal's capabilities can expand the observations already made on the previous cases on the adoption of ICT to support multimodal logistics whilst providing enhanced levels of visibility and collaboration. See table 5 for details on ICT capabilities for case 4.

ICT Planning and Execution Capabilities	***ICT Vehicular Communications Capabilities***
The use of advanced ICT to support multimodal operations is critical to the business of this terminal. The terminal runs an advanced proprietary in-house developed system. The system has become the platform where all information regarding terminal operations is exchanged and processed. The system manages key operations within the terminal including: gate operations, vessel operations, yard operations, vessel & container documentation, executive information system and customer billing. It also supports berth planning, ship planning and yard planning.	The main characteristic regarding haulage vehicles coming to the terminal facilities is the existence of two different information exchange platforms, one for internal yard tractors and the other for external trucks. Internal vehicles use the container terminal sophisticated its pager capable of WI-FI links and used in quayside operations directly linked to the main terminal system. The result is instant track and trace capabilities of internal yard tractors. Some of the characteristics of the its pager device includes: standard WI-FI connectivity, large external display, internal colour touch screen for driver and runs on linux. External haulage vehicles do not have access to the same functionality in terms of wireless communications links inside the port terminal. The tractor identity card (TID) is the software solution used by external trucks coming to the terminal to pick or unload a container.

Table 5. Details of ICT planning, execution and communications capabilities – case 4

In this terminal two areas directly related to multimodal logistics (involving road haulage and sea transportation) are gate and quayside operations. In the case of gate operations, external haulage truck drivers can make appointments through an appointment system (Tractor Appointment System) to collect or deliver containers. The checkpoint computer system scans the drivers' Tractor Identity Card (TID) or entry verification code, and from there the drivers can proceed directly to the yard for container pickup or discharge or wait until further notice using either a mobile terminal device or a voice-based system. When exiting the premises, the drivers swipe their TID cards to verify their identifications and the trucks are free to leave the site.

Presence of Coercion, Mimesis and Norms in Vehicular Communications. A clear example of coercion in this terminal can be seen in the use of the TID by external hauliers coming to the terminal. Given the preliminary role of this terminal in terms of rolling out ICT solutions, it also exerts a coercive role on other sister sites over the world in terms of adopting and adapting the same type of solutions.

Case 5. Port of Shanghai – Zhanghuabang Terminal

Terminal Characteristics. The three terminals comprising Shanghai Container Terminals handled 25 million TEUs in 2008. On its own Zhanghuabang terminal handled 3.6 million TEUs and the site operates a fleet of 80 yard trucks to handle and move containers within the terminal. The main purpose of the terminal is to serve as a domestic terminal from the south of China to the north of the country. It is mainly construction materials handled in the containers. The terminal also deals with international freight destined to Japan, South Korea and South East Asia. One berth in the terminal deals exclusively with containers to be shipped/coming from Japan. See table 6 for details on ICT capabilities for case 5.

ICT Planning and Execution Capabilities	***ICT Vehicular Communications Capabilities***
The terminal is run by the same parent company that runs the port of Hong Kong. That means the terminal uses a customised, in-house developed, terminal operating system. The Terminal Operational Procedure System (TOPS) comprises a number of modules used for vessel monitoring, planning and stowage as well as yard monitoring. The system has links to other external systems comprising wireless transmission, tariff management, electronic data interchange (EDI), transportation positioning, customer search and statistical analytical system.	The capability for vehicular communications within the terminal is subject to the use of a recognition card. Still the level of synchronisation enabled by the system makes possible to work step by step with the 3000 trucks per day coming to collect/deliver containers.

Table 6. Details of ICT planning, execution and communications capabilities – case 5

Presence of Coercion, Mimesis and Norms in Vehicular Communications.
In this case, coercion is exerted from the container terminal to the road hauliers coming to the terminal to load/unload a container. Also at the same time, this container terminal may adopt a mimicking approach as a way to adopt the practices taking place at the group's flagship terminal in Hong Kong.

DISCUSSION

A limitation of this research is that the study did not include all of the five top container ports in the world. It is based on the Humber Estuary UK, Zeebrugge Belgium, Busan South Korea, Hong Kong and Shanghai China. Researchers, managers and practitioners could use the results to envisage the future development of common ICT platforms/solutions that addresses the logistics needs of port terminals and the interaction with road haulage. Figure 2 shows the resulting ICT adoption and institutional isomorphism detected in the five case studies.

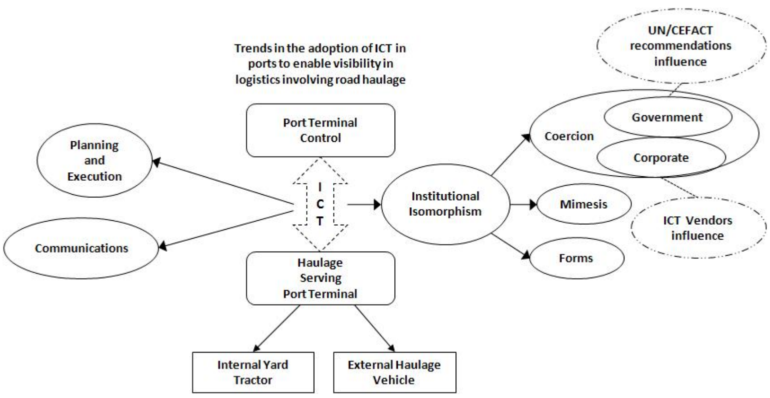

Figure 2. Resulting ICT adoption and institutional isomorphism detected in case studies

The adoption of ICT for enabling visibility in road haulage operations serving in a port offers several challenges. This study shows that the coercion exerted by government legislation regarding the adoption of ICT can ultimately have a major impact on the information visibility achieved in a port terminal especially by the road haulage operations serving it. Though ICT vendors have been considered powerful, the fact is that in the cases examined they did not represent an element of coercion in the adoption of ICT in the container terminals.

CONCLUSIONS

The study shows that terminal operators rely heavily in the use of corporate information systems for all task involving job/scheduling and transportation planning. On the other hand, the study shows that differences observed in the sites visited for this research can be associated to the way organisations have approached vehicle communications within the port facilities and the resulting track and trace capabilities which can impact visibility in the supply chain. The ICT survey of the sites visited shows a widespread use of different technologies including Wi-Fi and RFID-based devices mainly used in internal yard tractors.

The analysis of the use of ICT shows that the lack of a common ICT platform leads to the proliferation of technologies that may not be adopted by different players (terminal operators or road haulage companies). Harmonisation in the use of ICT to enable track and trace and its impact on visibility has to come from government initiatives that make compulsory the adoption of a certain standard or particular technology. On the other hand, terminal operators which may happen to be leading organisations in the industry have sufficient leverage power to force other players to adopt technologies developed in-house by them. Governments or logistics bodies/associations will have to step up to reach agreements that can lead to the standardisation of future technologies (e.g. use of a common technological platform) in order to reduce and mitigate the problems associated with ICT adoption and technology proliferation.

REFERENCES

Buganza T, Dell'Era C and Verganti R (2009) "Exploring the Relationships Between Product Development and Environmental Turbulence: The Case of Mobile TLC Services". Journal of Product Innovation Management, Vol. 26, 3, pp. 308-321.

Mondragon AEC, Lalwani CS, Mondragon ESC and Mondragon CEC, (2009) "Facilitating Multimodal Logistics and Enabling Information Systems Connectivity through Wireless Vehicular Networks". International Journal of Production Economics, Vol. 122, 1, pp. 229-240.

Davies I, Mason R. and Lalwani CS (2007) "Assessing the impact of ICT on UK general haulage companies" International Journal of Production Economics Vol. 106, pp. 12–27.

Ekelof PJ (2009) "The Emerging Pan-European Maritime Information Management Infrastructure" Proc of the 16th ITS World Congress Stockholm 2009, 21-25 Sep, Paper 3321.

Günther HO and Kim KH (2006) "Container terminals and terminal operations" OR Spectrum Vol. 28, pp. 437–445.

Hidalgo A and Lopez V (2009) "Drivers and Impacts of ICT Adoption on Transport and Logistics Services" Asian Journal of Technology Innovation, Vol. 17, 2, pp. 27-47.

Lai KH, Wong CWY and Cheng TCE (2006) "Institutional isomorphism and the adoption of information technology for supply chain management" Computers in Industry Vol. 57, 1, pp. 93–98.

Lai KH, Wong CWY and Cheng TCE (2008) "A coordination-theoretic investigation of the impact of electronic integration on logistics performance" Information & Management Vol. 45, 1, pp. 10-20.

Lun YHV, Wong CWY, Lai KH and Cheng TCE (2008) "Institutional Perspective on the Adoption of Technology for the Security Enhancement of Container Transport" Transport Reviews, Vol. 28, No. 1, pp. 21–33.

McAfee A (2006) "Mastering the Three Worlds of Information Technology" Harvard Business Review, Vol. 84, 11, pp. 141-149

Ngai EWT, Lai KH and Cheng TCE (2008) "Logistics information systems: The Hong Kong experience". International Journal of Production Economics Vol. 113, pp. 223–234.

Nyquist C (2009) "Secure and Efficient Intermodal Transports – Port Pilot Project in the Port of Gothenburg, Sweden" Proc 16th ITS World Congress Stockholm 2009, 21-25 Sep, Paper 3009.

Stahlbock R and Voß S (2008) "Operations research at container terminals: a literature update" OR Spectrum, Vol. 30, pp. 1–52.

UN-CEFACT (2010) http://www.unece.org/cefact/recommendations/rec_index.htm

Wong CWY, Lai KH and Ngai EWT (2009) "The role of supplier operational adaptation on the performance of IT-enabled transport logistics under environmental uncertainty" International Journal of Production Economics, Vol. 122, pp. 47–55.

APPLICATION OF RFID IN COLD CHAIN FOR FOOD QUALITY AND SAFETY

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1. INTRODUCTION

In the era of globalization, the food trade is rapidly growing not only in domestic level but also in international level across countries and continents. Perishable goods which are time and temperature sensitive in nature are of higher value and more vulnerable to temperature disturbances. The cold chain remains one of the most important ways to preserve perishables and deliver them to market in safe and good condition. Typically, a cold chain is a temperature controlled supply chain which relates to an uninterrupted series of production, storage, transportation and distribution activities of perishable goods. From the primary production to the final consumption stage, the goods are maintained in a safe, wholesome and good quality state (Beasley, 2006). Food safety refers to all hazards, whether chronic or acute, that may make food injurious to the health of the consumer, whereas food quality includes all other attributes (origin, colour, flavour, texture etc.) that influence a product's value to the consumer (FAO/WHO, 2003).

Globally, the incidence of food borne diseases is increasing and international food trade is disrupted by frequent disputes over food safety and quality requirements. FAO adheres to the food chain approach in managing food safety and quality as recognition of the responsibility of all actors in the food chain for the supply of food that is safe, healthy and nutritious (FAO, 2003). Food safety is an increasingly important public health issue. In industrialized countries, the percentage of the population suffering from food borne diseases each year has been reported to be up to 30%. In US, for example, around 76 million cases of food borne diseases, resulting in 325,000 hospitalizations and 5,000 deaths, are estimated to occur each year. The high prevalence of diarrhoeal diseases in many developing countries suggests major underlying food safety problems (WHO, 2007).

The need to monitor and maintain temperature is a critical issue as it impacts a lot on the social, economic and environmental performance of the cold supply chain. Temperature abuse in the cold chain can make microbial growth and spoilage of food so become the factor causing food borne illness. The International Institute of Refrigeration (IIR) indicates that about 300 million tonnes of produce are wasted annually through deficient refrigeration worldwide. The wastage problem is not particular to developing nations; for example, in US, the food industry annually discards USD 35 billion worth of spoiled goods. The wastage of food and resources used for growing unused products also a big issue for the environment (Flores and Tanner, 2008). Therefore, many food control systems need to be revised and strengthened if improvements are to be realized. This paper aims to provide the understanding of food supply chain concerning its critical issues such as safety and quality. Radio Frequency Identification (RFID) is suggested as a promising candidate to maintain and control the cold chain.

2. COLD CHAIN MANAGEMENT

Cold chain management refers to maintaining the proper temperature of the products through all the handoffs in the cold chain until it reaches the consumer (Smith, 2005). To achieve a sustainable and unbroken cold chain which can ensure safety and quality, the followings can be considered as the key factors.

2.1 Temperature Monitoring

Throughout the food chain, many kinds of products have to be handled under controlled environmental quantities, such as temperature, humidity, vibrations and light exposure. Among all these parameters, the temperature is usually the one of major concerns due to its huge variety of effects. If the temperature of some chilly foods exceeds specific limits, the rise in temperature of just a few degrees can cause microbial growth leading to the great decrease of quality and the increase of the risk of food poisoning (Carullo et. al., 2008). Therefore, perishable food products must be continuously monitored for safety and quality concerns throughout the whole supply chain. A breakdown in temperature control at any stage will impact on the final quality of the product (SARDI, 2006).

Temperature control in cold chain preserves both sensory and nutritional qualities, e.g. vitamin C losses in vegetables can be up to 10% per day when stored at a temperature of 2 °C; however, vitamin C loss can increase to over 50% per day when stored at temperatures of +20 °C. Most of the mechanisms of quality loss are determined by storage temperature and are accelerated with time spent above the recommended value. They are also promoted by temperature fluctuations (George and Gormley, 2000). Since a cold chain refer to a temperature controlled supply chain, temperature monitoring methods are vital to maintain a sustainable and unbroken cold chain. Current temperature monitoring systems like strip chart recorders or temperature data loggers are usually expensive and not automated, thus requiring manual inspection. RFID devices are more accurate and can be read without opening the container or package (Abad et al., 2009).

2.2 Legislative Directives

Legislation and good manufacturing practices (GMP) within the cold chain are designed to ensure effective control of safety and quality. Many process industries, notably those involving food and beverages, drugs, cosmetics, and medical apparatus, are subject to government regulation, and must maintain records that detail the lot identification of materials used in the manufacture of these products. Keeping record about time temperature history of the product is also needed to achieve cold chain integrity and customer’s confidence (George and Gormley, 2000).

In Europe, the EU directive 178/2002 requires mandatory traceability for all food and feed products sold within European Union countries (Folinas et al., 2006). In US, Bioterrorism Act of 2002 mentioned that the person who “manufacture, process, pack, transport, distribute, receive, hold, or import food” have to establish and maintain records. It also allows Food and Drug Administration (FDA) to inspect those records if there is a reasonable belief that an article of food presents a serious health threat (Levison, 2009).Therefore these legislative directives enforce the supply chain companies to trace the movement and to ensure the quality and safety of the product through the stages of production, processing, distribution and storage.

2.3 Cold Chain Visibility

Traceability is the ability to trace and follow a food, feed, food producing animal or ingredients, through all stages of production and distribution (Regattieri et al., 2007). It may relate materials, their origin, processing history, and their distribution and location after delivery. In particular product identification is fundamental, with physical characteristics such as volume, weight, dimensions, and packaging etc. The bill of material (BOM) structure is very useful for the tracing system to trace the parts which make the product (Montanari, 2008).

Traceability systems help firms isolate the source and extent of safety or quality control problems. This helps reduce the production and distribution of unsafe or poor-quality products, which in turn reduces the potential for bad publicity, liability, and recalls. The better and more precise the tracing system, the faster a producer can identify and resolve food safety or quality problems. If we have specific information about product, the processor can trace faulty product to the minute of production and determine whether other products from the same batch are also defective (Golan et al., 2004).

Many businesses follow this practice to protect themselves against liability. Shelf life or lot expiration tracking systems also require supporting inventory record subsystems. Typically, they track lot creation dates and expiration dates and provide for First-In, First-Out (FIFO) use of material as well as periodic aging reports used to predict material that is potentially expiring (Clement et al., 1992). But in cold supply chain, a retailer who knew which of the products had the shorter shelf life could put it out before the one with the longer shelf life - a process known as FEFO "First Expire, First Out" (Moore, 2009). Using a FEFO strategy based on cold chain RFID data, a food distributor can direct shipments to the specific store, or store group, in the most advantageous location (Edwards, 2007).

2.4 HACCP (Hazard Analysis and Critical Control Point)

A cold chain can be managed by a quality management system so called HACCP. It is a systematic preventive approach to food safety and pharmaceutical safety that addresses physical, chemical, and biological hazards as a means of prevention rather than finished product inspection. The system is used in all stages of food production and preparation processes including packaging, distribution, etc. (FSRIO, 2008)

HACCP is an important element in the control of safety and quality in food production. When properly applied, it provides a management tool aimed at complete commitment to product quality and safety (George and Gormley, 2000). There are 7 principles of HACCP which can be listed as follows: (1) Identify hazards, assess risk, and list controls; (2) Determine Critical Control Points (CCPs); (3) Specify criteria to ensure control; (4) Establish monitoring system for control points; (5) Take corrective action whenever monitoring indicates criteria are not met; (6) Verify that the system is working as planned; (7) Keep suitable records (NZFSA, 2003).

The HACCP system, as it applies to food safety management, uses the approach of controlling critical points in food handling to prevent food safety problems. Besides enhancing food safety, other benefits of applying HACCP include more effective use of resources, savings to the food industry and more timely response to food safety problems (FAO, 1998).

2.5 RFID, technology for cold chain

RFID technology is a wireless communication technology that enables users to uniquely identify tagged objects, people or animals. Today, RFID is applied widely in supply-chain tracking, retail stock management, parking access control, library book tracking, marathon races, airline luggage tracking, electronic security keys, toll collection, theft prevention, and healthcare (Lui et al., 2008).

An RFID system for cold chain purposes generally encompasses a sensor, a tag and a reader, that communicate with each other by means of radio transmission. RFID tags can store an EPC for logistics management purposes and embedded sensors can help to monitor environmental factors including temperature, humidity, and so on. RFID tags can be categorised into three types: passive RFID tags, active RFID tags and semi-passive tags (Flore and Tunner, 2008). Many active and semi-passive tags have incorporated sensors into their design, allowing them to take sensor readings and transmit them to readers. This helps RFID to embed environmental sensing in addition to identification therefore it can work as a cold chain management tool (Ho et al., 2005). The comparison of RFID tags can be seen in Table 1.

	Passive RFID tags	Semi-Passive tags	Active RFID tags
Power Supply	External (reader activated)	Internal battery powering only processing units and sensors	Internal battery also powering radio chip
Sensor Capability	1-3 meters	Up to 30 meters	Up to 120-150 meters
Readers	Read-only mostly	Read-write	Read-write
Applications	Consumer Product goods value chain Identification (people, animal feeds)	Harsh environments Mobile Applications with sensors	Longer range and larger memory requiring applications, tagging for bulk items container, ULD etc.

Table 1. RFID tags features (e-Business Watch, 2008)

Fitzgibbons (2004) stated that RFID has been linked to food safety for two primary reasons; the security of food supply from the threat of bioterrorism or contamination and consumer concern about the integrity of the food they eat. Thus today industry concerns include the ability to prevent a food safety incident and the ability to quickly and thoroughly handle its impact and prevent its recurrence when an incident occurs.

The conventional HACCP is found as a structured approach that involves careful recording of all details and actions in order to provide documentation that a safety management system is in operation and in full control of all hazards in food processing (McMeekin et al., 2006). Applying RFID technology replaced the paper work required under a HACCP system. By using the RFID system to build the automated portion, the personnel, material, and financial burden required to respond HACCP and GMP can be minimized. In summary, RFID technologies are said to improve the performance of perishable supply chains through the following uses:

(1) as a mean to identify items
(2) as a mean to track and trace the items in the supply chain
(3) as a mean to store real time environmental data (Flores and Tanner, 2008).

The features comparison between RFID and HACCP can be seen in Table 2.

	HACCP	RFID
Strength	Long history Understood among experts Prevention of food contamination identifying potential hazard in the food processing chain	advanced technology compared to bar code Hand-Free Operations Product traceability
Weakness	Seen as bureaucratic Often misunderstood Human errors Need training to all personnel in HACCP plan	'Bugs' may take time to work out Lack of Global Standard and Interoperability
Opportunities	Long operation history Existing systems could be Improved upon Re-training could occur	Could change the face of retail Potential to apply direct consumer tracking in the event of an emergency
Threat	Eventual obsolescence in the wake of improved technology	System crashes , Hacking, Loss of data, concerns about privacy and surveillance issues

Table 2. SWOT analysis of HACCP or RFID system (Kumar and Budin, 2005)

3. RFID APPLICATIONS IN FOOD INDUSTRY REVIEW

Many applications of cold chain in food industry by means of RFID have been reported. RFID is found as a very promising technology for the food sector, because it improves the management of perishable food, as well as tracking and tracing of food quality and safety problems. Therefore it is being widely adopted to track and trace all kinds of products and is seen as a tool for cold chain management.

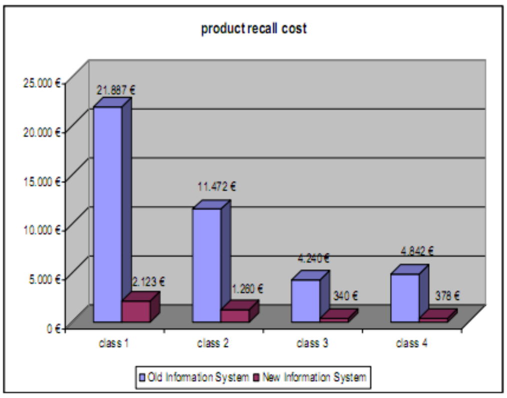
Abad et al. (2009) presented a real time traceability and cold chain monitoring system for foods by using smart RFID tag in intercontinental fresh fish logistic chain. They proved that the prototyped semi-passive smart tags achieve important advantages over traditional data loggers in term of storage, reusability, automation, visibility, concurrency and durability. Information systems are concerned with data capture, storage, analysis and retrieval. McMeekin et al. (2006) suggested a food safety information system which allows the perdition of microbiological safety and quality of food by monitoring the environmental information using active RFID. The database store information on the identification of foodborne pathogens, response of microbial populations to the environment and characteristics of foods and processing conditions in order to assist decision making process for food safety management problems.

In livestock and meat processing industry, RFID based chicken food traceability system (Chen et al., 2008) can monitor chicken from breeding, processing and selling stage. All the information about chicken throughout the chain are recorded by RFID and can trace back if the safety concerns arise. Mousavi et al. (2002) also proposed a solution using RFID technology to track meat production process until they become retail packs and trace individual prime cuts in the boning hall to the animal of origin. The concept of traceability in agriculture is reported by (Opara, 2003) classifying traceability into six elements (product, process, genetics, inputs, diseases and pest, measurement). Jedermann et al. (2006) proposed an intelligent container system using a combination of RFID, sensor networks, and software agents to trace fruit transports, demonstrating an effective use of RFID technology in fruit logistics. Also, RFID technology can be effectively applied in sushi restaurants to help improve their food safety, inventory control, service quality, operational efficiency, and data visibility (Ngai et al., 2008).

Product recalls are increasing concerns for food companies. Kumar and Budin (2006) presented the prevention and management of product recalls in the processed food industry. Findings from analysis suggested potential reduction of product recalls through recommended preventive measures including the use of HACCP and RFID systems. Regattieri et al. (2007) suggested a general framework for traceability of food products with RFID having Italian cheese production as an example. By using the RFID system, cheese manufacturers are able to trace the product along the chain with great precision and can apply possible re-call strategies very rapidly.

As an example, Karagiannaki and Pramatari (2009) reported a work that was undertaken for a company that deals with frozen food regarding the requirements analysis, development and pilot implementation of a RFID-enabled traceability system within the central warehouse. The focused problem relates to the product recall cost with regard to the amount of money and time that is needed to recall a suspicious batch of a product. In order to produce more accurate results, all the frozen products that the company produced are categorised into four major classes according to two important characteristics, volume and cost of production: (a) High production volume and low production cost (b) High production volume and high production cost (c) Low production volume and low production cost (d) Low production volume and high production cost.

The profit can be calculated from the total benefit that corresponds to the aggregation of the benefits of each separate class that occur in case of a product recall. After mathematical analysis, the RFID-enabled traceability system indicated a spectacular reduce in recall cost for all the product classes at about 90% from the initial cost. The following figures indicates the actual recall costs for each class each time a recall of a product is being conducted.



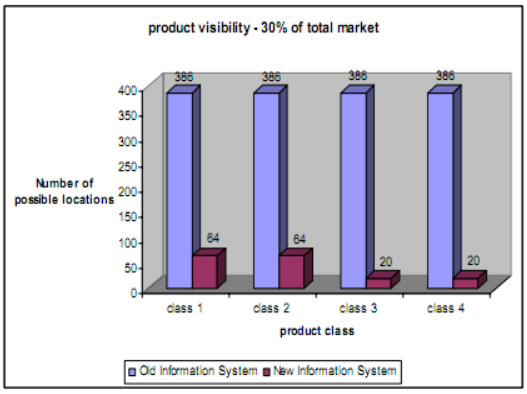


Fig1.Total recall cost for each product class Fig2. Possible location of a defective product

As shown in Fig1., the cost reduction is found as a consequence from the reduction of the number of possible locations that a defective product is located and it also directly relates to the volume of production (Fig2.).

4. DISCUSSION

As we mentioned before, RFID is found as a promising technology that enables to improve the handling practices, to gain inventory control and to increase product visibility. The availability of embedded environmental sensing in RFID fulfils the requirement of cold chain to monitor and control environmental parameters. Therefore, other sensor system with extra cost is not needed for sensing task. Due to the frequent accident of foodborne illness and incidents, RFID has been found as a track and trace tool to identify the sources of food contamination, food-borne illness and the recipients of contaminated food in product recall and seizures (Levinson, ov2009). An intelligent, responsive and knowledge-based decision support system reported by (Jedermann et al., 2006; Kumar and Budin, 2006; McMeekin et al., 2006) are found just a few in previous research but it could be a future framework which can tackle with the challenges faced by perishable supply chain industry today.

Most cold chain applications indicated that RFID offers a number of potential benefits to production, distribution, and retail chain improving food quality control, safety, visibility, traceability, inventory management, service quality, operational efficiency and saving labour costs. However, a number of concerns have been raised in regard to the use of RFID in cold chain applications. In RFID system, all the communication and data traffic rely on the reader and make it as a congestion point. For additional monitoring task, RFID systems need to handle a large amount of environmental data in addition to their primary identification data so its interpretation can be overwhelming.

Flores and Tanner (2008) indicated that RFID has limitations such as relatively high cost, difficulties in calculating a ROI and reliability and accuracy although it can provide numerous benefits in temperature monitoring and performance of perishable supply chains. RFID data loggers are available in high quantities, but they require manual handling because of their low reading range. If a gate reader scans items automatically upon arrival at the warehouse, the reading range has to cover several meters. Also these tags take around five seconds to transfer recorded temperature values over the RFID interface (Jedermann et al., 2009). Research directions are related mainly to tackling general challenges of designing semi-passive tags, such as extending the reading range and prolonging the battery life (Lui et al., 2008). The development of a global RFID standard would improve the uptake of the technology and would also help to decrease the confusion around the required frequencies and radio spectra in each country.

Transparency and collaboration across the supply chain are the greatest challenges for the successful adoption of RFID technologies (Flores and Tanner, 2008).

5. CONCLUSION

Cold chain management requires very careful temperature control and quick reactions especially in perishable food supply chain. It is found that such application requirements meet with RFID technology's capabilities. This paper highlight review only on food cold chain research although the cold chain covers for other types of temperature sensitive products such as pharmaceuticals and chemicals. RFID and related information technology can result in a recall that is more surgical, more precise and therefore much less costly. The damage to brand identity, consumer confidence and product allegiance can be minimized. To overcome the challenges of food safety and quality today the collaboration of all actors in supply chain is essential.

REFERENCES

Abad, E., Palacio, F., Nuin, M., González de Zárate, A., Juarros, A., Gómez, J.M. and Marco, S. (2009), "RFID smart tag for traceability for traceability and cold chain monitoring of foods: Demonstration in an intercontinental fresh fish logistic chain", Journal of food engineering, Vol. 93, No. 4, Aug 2009, pp. 394-399.

Beasley, S. D.(2002)."Helping Exports Keep Their Cool", AgExporter, Vol.14,No.4,pp.4-5.

Carullo, A., Corbellini, S., Parvis, M., L.Reyneri, L. and Vallan, A.(2008), "A Measuring System for the Assurance of the Cold-Chain Integrity", In proceedings of the IEEE International Instrumentation and Measurement Technology Conference, Vancouver, Canada, May 2008, pp. 1598-1602.

Chen, R.S., Chen, C.C., Yeh, K.C., Chen, Y.C. and Kuo, C.W.(2008), "Using RFID Technology in Food Produce Traceablity", WESAS Transactions on Information Science and Applications, Nov 2008, Vol. 5, No. 11, pp. 1552-1560.

Clement, J., Coldrick, A. and Sari, J. (1992), "Manufacturing Data Structure: Building foundations For Excellence with Bills of Materials and Process Information", Wiley,

e-Business Watch (2008), "RFID Adoption and Implicaitons", Study Report, No. 07/2008.

Edwards, J. (2007), "Cold Chain Heats Up RFID Adoption", RFID journal, April 2007,

FAO (1998), Food and Agriculture Organisation of the United Nations, "Food Quality and Safety Systems- A Training manual on food hygiene and the hazard analysis and critical control point (HACCP) system", Rome, 1998, http://www.fao.org/docrep/w8088e/w8088e00.HTM [Accessed 16/3/2010]

FAO (2003), "FAO's Strategy for a Food Chain Approach to Food Safety and Quality: A framework document for the development of future strategic direction", http://www.fao.org/DOCREP/MEETING/006/Y8350e.HTM [Accessed 16/3/2010]

FAO/WHO(2003), "Assuring Food Safety and Quality: Guideline for Strengthening National Food Control System", FAO Food and Nutrition Papers-76.

Fitzgibbons, D.(2004), "RFID and Food Safety", Deloitte Consulting, http://rfid.ctu.edu.tw/rueychi/8_lab/RFID_reference/5/us_cb_RFIDFoodSafetyApr05.pdf [Accessed 16/3/2010]

Flores, S.E. and Tunner, D.(2008), "RFID technologies for cold chain applications", Review article, International Institute of refrigeration, Bulletin 2008-4, July 2008, pp. 4-9.

Folinas, D., Mankas, I. and Manos, B. (2006), "Traceability data management for food chains", Emerald British Food Journal, Vol.108, No. 8, 2006, pp. 622-633.

FSRIO (2008), "A Focus on Hazards Analysis and Critical Control Point", Food Safety Research Information Office, United States Department of Agriculture, http://fsrio.nal.usda.gov/document_fsheet.php?product_id=227 [Accessed 20/3/2010]

George, M. and Gormley, R. (2000), "Managing the Cold Chain for Quality and Safety", Flair-Flow Europe Technical Manual 378A/00,May 2000, http://www.teagasc.ie/ashtown/research/preparedfoods/managing_the_cold_chain.pdf[Accessed 15/2/2010]

Golan, E., Krissoff, B. and Kuchler, F. (2004), "Food Traceability: One Ingredient in a Safe and Efficient Food Supply", Amber Waves, April 2004. http://www.ers.usda.gov/AmberWaves/April04/Features/FoodTraceability.htm [Accessed 15/2/2010]

Ho, L., Moh, M., Walker, Z., Hamada, T. and Su C. F. (2005), "A prototype on RFID and Sensor Networks for Elder Healthcare: Progress Report", In Proceedings of Conference on Special Interest Group on Data Communication, SIGCOMM'05, Philadelphia, PA, USA, Aug 2005, pp.70-75.

Jedermann, R., Behrens, C., Westphal, D. and Lang, W. (2006), "Applying Autonomous Sensor System in Logistics: Combining Sensor Networks, RFIDs and Software Agents", Journal of Sensors and Actuators A:Physical, Vol. 132, No. 1, Nov 2006, pp. 370-375.

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, 65,2, 145-154.

Karagiannaki and Pramatari (2009), "Leveraging RFID-enabled Traceability for the Food Industry: a case study", The HERMES Newsletter, Issue No.55, Apr-May 2009

Kumar, S. and Budin, E.M., (2006). "Prevention and management of product recalls in the processed food industry: A case study based on an exporter's perspective", Technovation , Vol. 26, pp. 739–750.

Levinson, D.R.(2009), "Traceability in the Food Supply Chain", March 2009. http://oig.hhs.gov [Accessed 22/2/2010]

Liu, H., Bolic, M., Nayak, A. and Stojmenovic, I. (2008), "Taxonomy and Challenges of the Integration of RFID and Wireless Sensor Networks", IEEE Network, Vol.22, No. 6, Nov-Dec 2008, pp. 26-35.

McMeekin, T. A., Baranyi, J., Bowman, J., Dalgaard, P., Kirk, M., Ross, T., Schmid, S. And Zwietering, M.H. (2006), "Information systems in food safety management", International Journal of Food Microbiology, No. 112, pp. 181-194

Montanari, R.(2008), "Cold Chain tracking: a managerial perspective", Int'l Journal of trends in Food Science & Technology, Vol. 19, 2008, pp. 425-431.

Moore, B. (2009), "Using RFID-Based Sensor Technology", Article in RFID Monthly, 15th June 2009, http://www.rfid-monthly.com/?p=1224 [Accessed 15/2/2010]

Mousavi, A., Sarhavi, M., Lenk, A., Fawcett, S. (2002). "Tracking and traceability in the meat processing industry: A solution", British Food Journal, 104 (1), 7–19.

Ngai, E.W.T., Suk, F.F.C. and Lo, S.Y.Y. (2008), "Development of an RFID-based sushi management system: The case of a conveyor-belt sushi restaurant", International Journal of Production Economics, No.112, pp. 630-645.

NZFSA (2003), New Zealand Food Safety Authority, "An Introduction to HACCP", May 2003, www.nzfsa.govt.nz/processed-food-retail-sale/fsp/haccp.pdf [Accessed 22/4/2010]

Opara, L. U.(2003), "Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects", Food, Agriculture & Environment Vol.1, No.1, pp. 101-106.

Regattieri, A., Gamberi, M., Manzini, R. (2007), "Traceability of food products:General framework and experimental evidence", Journal of Food Engineering, Vol. 81, No. 2, pp. 347–356.

SARDI (2006), South Australian Research and Development Institute, "Maintaining the Cold Chain: Air Freight of Perishables", http://www.australianairfreight.com/vac/pdfs/airfreight_perish.pdf[Accessed 18/3/2010]

Smith, J. N. (2005). "Specialized Logistics for a Longer Perishable Supply Chain", World Trade, 18(11), pp. 46-48.

WHO (2007), http://www.who.int/mediacentre/factsheets/fs237/en/ [Accessed 18/4/2010]

SUPPLY CHAIN in A BOX (SCiAB)

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INTRODUCTION

Supply chain management software solutions are tools and processes that are developed to deliver effective supply chain by managing logistics, supplier-customer relationships, and quality of products. In the ideal, this management software should provide an end to end view of the supply chain process and accurate information that helps in making business decisions. Typically, a well integrated supply chain management software should help firms synchronize supply with demand by managing distribution, transportation and logistics, supply network visibility, design optimization, collaboration, and analytics across the extended supply chain. Over the years, supply chain management software solutions have evolved to provide information for the seamless integration of strategic options and tactical operational planning. For instance, supply chain management software in the retail sector today already provides solutions such as shelf availability, inventory visibility, responsive logistics, warehouse draw downs, integrated distribution channel planning, integrated transportation, and route planning that cater to the needs across different functionalities of the supply chain. Retailers are leveraging on such supply chain management software not just for managing supply chain activities but also gaining competitive advantage.

With the growth in contract manufacturing particularly in Asia and the increasing importance of service-based supply chains in Europe, there is a growing need to develop and integrate tools found in supply chain management software. While the leaders in such software are well acknowledged and operate in a distinct space such as those of SAP with its 11-percent market share, the other major software vendors, including Catalyst, G-Log, HighJump, and Logility, i2 Technologies, Descartes Systems, and Manugistics have to respond more proactively else they risk watching their SCM revenues drop. SCM vendors experiencing revenue growth are the ones that are looking closely at what customers need and are trying to service those needs. Today, customers need more than good piecemeal software. Instead, they want a complete suite of package which are basically retrofitted for today's business.

This paper seeks to present a supply chain in a box, which is just a collection of SCM tools built on a user friendly, system independent and language independent platform. Before we present the SCM tool, we highlight some of the relevant literature.

LITERATURE REVIEW

Kim (2001) first proposed an XML-based language for sharing Operations Research (OR) models, albeit with OR spanning a wide variety of applications; hence creating a generic platform for the entire domain of problems is performed at the expense of the details. Qiao et al. (2003) describe an XML standard for manufacturing simulation, with Lu et al. (2003) looking at a case study of Boeing. Fishwick (2002) describes a two-layer (MXL and DXL), XML-based modeling and simulation system that also serves manufacturing simulation. To allow inter-operability between the simulation software, Kilgore (2002) looks at a platform-independent simulation language while Weidemann (2002) proposes a language-independent standard. A recent framework Simulation Study Definition and Report Structure (SSDRS) is proposed by Kuhn (2004) which can also accommodate distributed network systems.

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The Mathematical Programming System (MPS) format served as a problem definition format for commercial and open source (MP) Mathematical Program solvers. The XML-based extensions OptML and SNOML were introduced by Kristiansson (2001), and Lopes and Fourer (2001) respectively. Fourer et al. (2003) formally present LPFML as an XML based schema. In Fourer et al. (2006), OSiL (Optimization Services instance Language), is introduced by extending applications to mixed-integer, quadratic, and nonlinear programs.

Birge et al. (1987) and Gassmann (2005) present the XML based schema for stochastic problems, coining the term SMPS. Their work on the schema for stochastic problems has been further extended by Gassmann and Kristjansson (2008). Fourer et al. (2009) define the stochastic schema as part of a unifying schema for all types of mathematical problems. For other specific areas such as in a distributed environment, El-Gayar and Tandekar (2007) propose a XML-based model for sharing and reuse.

In the field of supply chain management, there has been interest in developing generic frameworks which would incorporate the distinctive features of supply chains and thus act as a common platform. While there is a variety of applications in supply chain management and optimization, simulation is an area visited in the literature with this objective. Jain (2008) looks at building a generic supply chain simulation capability. Such a capability aims to reduce the effort and expertise required in building a simulation model for supply chains. A specific methodology for manufacturing-oriented supply chain simulation, Manufacturing Information Model for Simulation (MIMS), is also proposed by Qiao and Riddick (2004).

Chatfield & Harrison (2004), and Chatfield et al. (2009) introduce a Supply Chain Modelling Language (SCML) as a platform that enables supply chain problem instance reuse and sharing, providing a common format for software interoperability. Using the methodology-independent Extensible Markup Language (XML)-based markup language for storing supply chain structural and managerial information, Chatfield et al. (2009) define a common platform for supply chain problem description and utilize the SCML format for simulation modeling and developing a supply chain simulation tool (SISCO) as found in Chatfield et al. (2006). We present in this paper a version of the integrated supply chain set of tools for use in an independent platform.

Overview of SCiAB

This section discusses the Supply Chain in A Box (SCiAB) application architecture as shown by Figure 1.

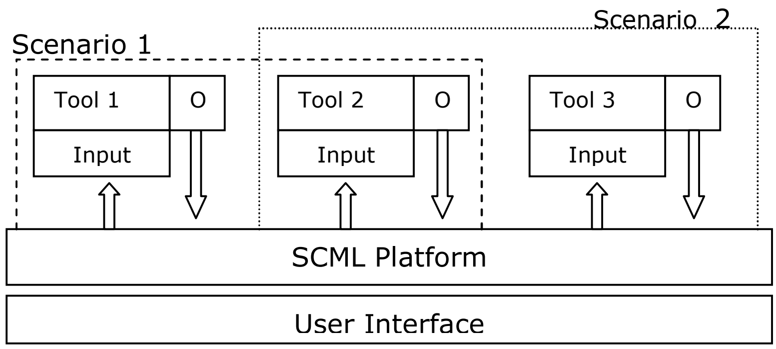


Figure 1: Application architecture

SCiAB consists of a set of user interfaces, a common communication platform and supply chain tools. At a glance, it is clear that the tool's inputs are stored in the communication platform and the tool's output are stored back to the communication platform as well.

SCML Platform

The key aspect in this application is to make data sharing across supply chain applications possible. The purpose of the data sharing is to reduce redundant work to re-input dataset for different applications. SCiAB implements the Supply Chain Modeling Language (SCML) of Chatfield & Harrison (2004) as its common data sharing platform. All the supply chain replications are clearly defined in this platform. SCML is an open XML based supply chain data modeling. This format is readable for most applications.

In order to describe supply chain information, based on the SCML framework, we divide the supply chain information into 5 main classes: *nodes, arcs, components, actions* and *policies*. Classes other than nodes and action represent the physical aspect in the supply chain. In this paper, other than representing the physical aspect of the supply chain, a component class is also used to define all the supply chain tools needed in a scenario.

Nodes represent the location of a supply chain player. This player can be a factory, distributor, wholesaler, retailer, customer, or the others in the supply chain. Each node has its own set of properties such as input and output, demands, storage capacity, costs, actions that possibly occur at a particular node and applicable policies at the node.

Nodes are connected by *arcs*. An arc can be defined as the transportation mode to transport goods/information from a node to another node. An arc also has a set of properties such as the arc's mode (land, rail, water, air, or telecommunications), capacity of the carriers, container size, actions that possibly occur on a particular arc, policies applicable at the arc, and all cost related properties such as rates, basic cost, maintenance cost, and expansion cost.

The actual goods that are created, consumed, used, or transported in the supply chain is defined in *Components*. These include the material type and the labor cost. Other than that the value, the characteristics of the physical goods and the method of its creation must also be defined.

Another important aspect within the supply chain, *Actions*, must be provided. Actions include the demand, order replacement, order processing, transportation, receiving or shipping. Circumstances that trigger the actions to happen are also defined in policies. Lastly, the relationship between the supply chain players and the constraint that will trigger an action to occur is defined inside *Policies*.

GUI-driven application

In this application, a set of friendly user interfaces is designed. Though the GUI-driven environment is not novel, the focus on the supply chain is that SCiAB makes the scenarios building process easier by allowing a user to focus on the supply chain data and information. Reducing a user's effort to do the modeling task will encourage the user to concentrate on producing more accurate supply chain information that would describe the actual supply chain situation.

SCiAB Components

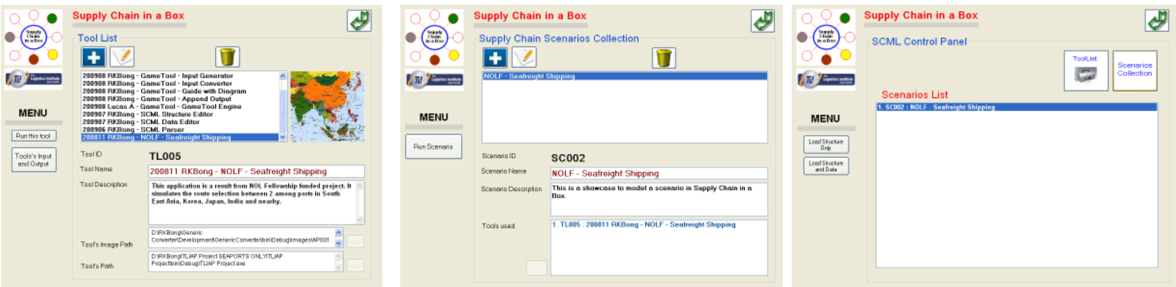
SCiAB has 3 main components. Each of the components serves a different purpose. Figure 2 below shows the main components in SCiAB.

- Tool List
  Tool List is a collection of supply chain tools. A supply chain tool should be an independent tool, which has its own input and output that can be executed anytime and when needed. Supply chain tools that are registered should be able to read data from SCML directly or it must have the SCML data parser built in the tool. Otherwise, an external parser to parse SCML data files for the particular engine is required. Clicking on the ToolList will return a page with all the supply chain tools registered in SCiAB. Figure 3(a) shows the screen capture of this feature.

- SCML Control Panel
  The SCML control panel is a tool to define and modify data for supply chain tools or scenarios. This control panel allows a user to define data required for a scenario, input and output data format of a specific tool. This editor is built on a class-based view according to classes and subclasses in the SCML framework. Figure 3(c) shows the screen capture of the SCML control panel.

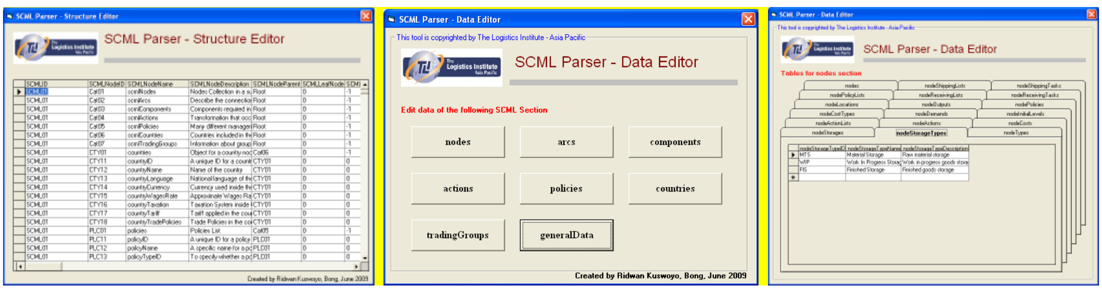
- Scenario Collection
  The Scenario Collection is a feature to define supply chain scenarios and select the tools required for the scenarios. A supply chain scenario is defined as a supply chain problem that can be solved by the collection of supply chain tools. Creating a supply chain scenario also requires the adding of supply chain tools into the scenarios. Adding the supply chain tools should be done in a sequential order if a tool's inputs depend on the previous tool's outputs since the execution is in sequential order. Figure 3(b) shows the screen capture of the scenarios collection.

Figure 2: Application main menu



(a) (b) (c)
Figure 3: Application features

Clicking the menu on the SCML control panel will lead us to edit the SCML data structure or to define the data for the SCML feature. The features' screen captures are shown in Figure 4 below. Figure 4(a) defines the SCML data structure. The SCML structure can be edited accordingly through this feature. Figure 4(b) shows all main components (classes) of the SCML framework, while Figure 4(c) displays the subclass of a certain component and the facility to edit data for the corresponding subclass. This feature provides an easy and user friendly way to put data into SCML platform.



(a) (b) (c)
Figure 4: SCML Structure and Data Editor

Supply Chain Tools' Input and Output

The Supply Chain Tool will extract data for it to run from the SCML data file. If a particular tool produces an output, then the output will be stored in the SCML data file. Output stored in SCML data file has to be in accordance with the other tools' input format. By doing this, the user's effort to re-format data or to feed in the data manually to a specific tool is reduced.

As mentioned before, besides materials / information that can influence the supply chain, supply chain tools are also stored inside the *components* section. As such, there is a slight modification in order to accommodate this component. The a*ction input* subclass in the original SCML platform is used to store the name of a component and the amount used in the supply chain while the component *action output* is used to store the name of component and the amount produced by the action. Further use of this class is done such that the action input is used to store the component name and its input format while the action output is used to store a component name and its output format.

GENERATING SUPPLY CHAIN SCENARIOS

This section describes the generation of supply chain scenarios in SCiAB. Consider a ship routing optimization to find the shortest travel time route or the lowest cost route as the sample for the scenario. Tools that are required for this scenario is an input tool to input a query, an optimization tool to search for the best routes, and a viewer tool to display its results.

To first step to implementing this is to register all tools into the ToolList followed by specifying its input and output formats. In this example, the optimization tool will obtain input from the input tool as well as the viewer tool will get the input from the optimization tool. So, the output format from the input tool must be the same as the input format for the optimization tool. Also, the output format from the optimization tool must be the same as the input format for the viewer tool. Every registered tool will automatically be added as a component in the SCML data file.

Following the step above, the next logical step is to create a scenario from Scenario Collection and add all the tools required in sequential order. The next step is to define the ports included into the route, ship destination links and schedules, the cost in days as well as in dollar value, the shipping policies, the action/decision taken into the SCML data file through the data editor. The ports and all its attributes included into the route will be put into the *Nodes* class. The ship destination links and schedules, the cost associated with every link will be put into the *Arc* class. The shipping policies are put into the *Policies* class. All actions / decisions taken will be put into the *Action* class. Generating a scenario process is complete after putting all the required data into the SCML data file. The scenario is now ready to run.

CONCLUSION

The SCiAB is a powerful and easy-to-use WYSIWYG SCML application for collaborative supply chain modeling across different geographies and companies who are keen to obtain a visual perspective of the end-to-end supply chain optimization scenario building, especially smaller companies. It is also vendor independent and system independent. While data is being exchanged using SCML, there will be no loss of data even between systems that use totally different formats. In this way, SCiAB brings to the business community of shippers and service providers all the potential benefits of data quality, content, highest productivity, validity and consistency in terms of data and network structure, rules and business conventions, and automated supply chain optimization in a seamlessly integrated environment.

REFERENCES

Birge JR, Dempster MAH, Gassmann HI, Gunn EA & King AJ (1987), "A standard input format for multiperiod stochastic linear programs", *COAL Newsletter*, 17, 1-19.

Chatfield, DC & Harrison, TP (2004). "XML-based supply chain simulation modeling", in *Proc. of the 2004 Winter Simulation Conference.*

Chatfield DC, Harrison, TP & Hayya, JC (2006), "An XML-centred approach to creating object-oriented supply chain simulation models", *International Journal of Simulation and Process Modelling*, 2, 3/4, 115-123.

Chatfield DC, Harrison TP & Hayya, JC (2009), "SCML: An information framework to support supply chain modeling", *European Journal of Operational Research*, 196, 2, 651-660

El-Gayar O & Tandekar K (2007), "An XML-based schema definition for model sharing and reuse in a distributed environment", *Decision Support Systems,* 43, 3, 791-808.

Fishwick PA (2002), "Using XML for simulation modeling", in *Proc. of the 2002 Winter Simulation Conference*, 616–622.

Fourer R, Lopes LB & Martin RK (2003), *LPFML: A W3C XML Schema for Linear Programming*, unpublished technical report, Department of Industrial Engineering and Management Sciences, Northwestern University.

Fourer R, Ma J & Martin RK (2006), OSiL: An Instance Language for Optimization, Technical report, Department of Industrial Engineering and Management Sciences, Northwestern University.

Fourer R, Gassmann HI, Ma J & Martin RK (2009), "An XML based schema for stochastic programs", *Annals of Operational Research*, 166, 1, 313-337.

Gassmann HI (2005) *The SMPS Format for Stochastic Linear Programs*. Available at http://myweb.dal.ca/gassmann/smps2.htm.

Gassmann HI & Kristjánsson B (2008), "The SMPS format explained", *IMA Journal of Management Mathematics*, 19(4), 347–377.

Jain S (2008), "Tradeoffs in building a generic supply chain simulation capability", in *Proc of the 2008 Winter Simulation Conference*.

Kilgore RA (2002), "Simulation web services with .NET technologies", in *Proc. of the 2002 Winter Simulation Conference*, 841–846.

Kim H (2001), "An XML-based modeling language for the open interchange of decision models", *Decision Support Systems* 31, 429–441.

Kristiansson B (2001), "How new technologies such as XML and SOAP allow OR to provide Web-based services", accessed on 15 May 2010 from http://www.maximal-usa.com/slides/Svna01Max/index.htm.

Kuhn W (2004), "Standardisation of simulation studies by use of XML-technology", in *Proc. of Summer Computer Simulation Conference*, 334-342.

Lopes L & Fourer B (2001), "An XML-based format for communicating optimization problems", accessed on 15 May 2010 from http://senna.iems.northwestern.edu/xml/presentations/Lopes-FourerMiamiBeach01.

Lu RF, Qiao G & McLean C (2003), "NIST XML simulation interface specification at Boeing: A case study", in *Proc. of the 2003 Winter Simulation Conference,* 1230–1237.

Qiao G, Riddick F & McLean C (2003), “Data driven design and simulation system based on XML”, in *Proc. of the 2003 Winter Simulation Conference,* 1143–1148.

Qiao G & Riddick F (2004), “Modeling information for manufacturing-oriented supply-chain simulations”, in *Proc. of the 2004 Winter Simulation Conference*, 1184-1188.

Weidemann T (2002), “Next generation simulation environments founded on open source software and XML-based standard interfaces”, in *Proc of the 2002 Winter Simulation Conference*, 623–628.

SECTION 7 – Environmental Sustainability and Green Logistics

MILLENNIUM DOME TO O2: TRAVEL PLAN FOR A NEW ENTERTAINMENT FACILITY

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ABSTRACT
Purpose
The travel plan designed for the O2 is described in this case study as the teaching materials to help student understand how to make a travel plan for a newly developed leisure venue and the factors to be considered in making the plan. It illustrates how to design multimode transportation and mode split for passenger travel. It also allows students to consider environmental protection issues when developing a green travel plan for a new area.

Design/methodology/approach
This case is mainly secondary research and compiled from published resources about The O2, survey outcomes and monitoring reports provided by Anschutz Entertainment Group (AEG) (2006, 2007), as well as other relevant literature.

Findings
The travel plan is developed with comprehensive targets and a monitoring programme to encourage environmentally sustainable travel choices by visitors to the O2, and devised a coordinated approach for the benefit of the environment around the O2. Key strategies proposed in the travel plan include the appointment of a full time transport coordinator to work with partnership organisations, including the London Borough of Greenwich (LBG), Transport for London (TfL) and other transport operators, improvements to bus and underground services and a new river service from central London.

What is original/value of paper
The travel plan endeavours to encourage environmentally sustainable travel choices by visitors to the O2. The value of describing the travel plan in the case brings the readers a coordinated approach for the benefit of the environment around the O2. This seeks to encourage visitors to the O2 to use alternative modes to the private car or make more efficient use of existing modes and to introduce the health benefits of more sustainable travel.

INTRODUCTION
According to a European Commission paper (2001), by 2010, economic growth will automatically generate greater needs for mobility of goods services (by 38%) and passengers (by 24%). However, the transport sector is a major source of CO_2 emissions, with urban transportation generating more than half of the total (Lidskog et al., 2003). The resulted global warming and climate change due to CO_2 emission bring the negative effects on environment, society and economy (Steg and Gifford, 2005).

Therefore, a sustainable transportation network needs to be constructed to meet current transportation needs in such a way that the ability of future generations to meet their transportation needs is not compromised (Black,1996), and make a balance of economic, environmental, and social quality (Loo, 2002).

The millennium dome in London was redeveloped as a world-class entertainment facility and renamed as the O2 in June 2007. As there is only one underground tube line and several bus routes before it was opened in June 2007, the O2 becomes a bottle neck when a large number of passengers need to get into and out of the O2. To solve the problem, AEG, as the owners of the O2, appointed Transport Planning Practice (TPP) in May 2006 to produce a travel plan for the redevelopment of the O2.

The success of the O2 redevelopment is closely related to the availability of the transportation network and effectiveness of the travel plan. According to the two surveys conducted after the O2 opening, the initial travel plan proves to be successful in promoting public and more sustainable travel modes, and it also shows that travel patterns can be influenced through appropriate marketing and communication to maximise the use of sustainable modes by visitors.

In the next section, the research objectives and methodologies are explained, and then the travel plan visions, objectives and targets are described, followed by the measures to achieve the travel plan targets, and the monitoring of the travel plans. Finally the conclusions are provided to summarise the contributions of the travel plan.

RESEARCH OBJECTIVES AND METHODOLOGY

This case can be used for students to better understand the process of designing travel plans for a leisure venue, from setting up the comprehensive targets, to developing plans for the targets, finally to monitoring and adapting the plans. It also allows students to consider environmental protection issues when developing a travel plan for a new area. Students are also encouraged to formulate their own travel plans for the case.

The research methodologies used in the research are mainly secondary research. A comprehensive literature is reviewed in the areas of green logistics and sustainable public transport to understand the achievements and the need of sustainable transport. The literature reviewed range from journal articles, conference proceeding, government reports, and internet resources, providing concise, up-to-date and reliable information, so that the authors can track down the research progress in the above areas. The O2 travel plan document AEG (2006), which is produced by TPP for the redevelopment of the O2, is used as the main secondary resource for the plan targets, the existing transportation conditions, travel demand patterns, and measures to achieve the targets.

The author also reviewed the O2 travel plan monitoring report AEG (2007) produced by the TPP to report how the initial plan targets are assessed and adapted. The secondary data obtained from AEG are reliable but not up-to-date, and most of the planned transport infrastructure has been implemented when the case study is produced, such as the planned new bus routes and river pier. In addition, a number of published resources (including online resources) about the development of the O2 are reviewed to understand the background and planning history of the travel plan.

TRAVEL PLAN VISION, OBJECTIVES AND TARGETS

The O2 travel plan aims to bring a coordinated approach to solve the bottle neck traffic problem to the O2, and encourage environmentally sustainable travel choices by visitors to the O2.

To achieve the aim, the objectives of the O2 travel plan are as set follows: i) ensure that non-car travel modes are accessible, easy to use and have sufficient capacity to accommodate all proposed events; ii) maximise the use of the sustainable travel modes by visitors, by influencing their travel patterns through appropriate marketing and communication; iii) keep the car parking provision at the constrained level of 2,200 spaces;

When the travel plan is initiated, there is one London underground service (Jubilee line) directly connected to the O2; one Docklands Light Railway (DLR) requiring a bus interchange to the O2; six bus routes serving the O2, and four train stations requiring a bus interchange to the O2. Based on the existing transportation infrastructure and the best available date about demand pattern (obtained from a transport assessment undertaken in 2002 by an external consultant), the initial travel plan targets are set up and the mode split is predicted in Table 1.

Car		***Motorcycle***	***Taxi***	***Bus***	***Underground***	***Coach***	***Cycle***	***Walk***	***River***
Driver	***Passenger***								
8%	**14%**	**1%**	**2%**	**9%**	**52%**	**9%**	**1%**	**1%**	**3%**

Table 1 Visitor two-way target mode-split for the O2

The use of public transport is set to be 64% (52% underground, 9% bus and 3% river) in the initial targets. To assess the initial targets, the travel plan is reviewed within the first three months of the opening of the O2 to establish a baseline. Beyond this, an annual survey will be undertaken and compared against the baseline data. If required, a reduction target will be set after the baseline surveys. However, due to the time constraint, the results of annual survey are not available yet, and they are not included in the case study.

MEASURES TO ACHIEVE TARGET

In order to achieve the target mode split set in the travel plan, the measures are set out to build necessary infrastructure, assess the capacity of various transportation modes, and deliver the target. To ensure the delivery and the management of the travel plan, a transport coordinator is appointed, and his responsibilities include i) monitoring the travel demand and reviewing the travel plan measures and targets accordingly; and ii) liaising with LBG and TfL to implement the travel plan and make adjustments to service provisions if appropriate.

- **Infrastructure** i) the transport coordinator regularly liaises with TfL and Jubilee line to ensure that arena events are not scheduled during periods of planned engineering works; ii) TfL and LBG will provide up to seven additional bus services to accommodate the anticipated demand in peak period; iii) the TPP undertakes a study into the feasibility of an enhanced river boat service and formally requests it if appropriate.

- **Transportation capacity** within the first 3 months after the O2 opening, i) the TPP undertakes train and bus capacity surveys for two different events; ii) the transport coordinator monitors passenger demand for the river service during at least one event; iii) the transport coordinator ensures the controlled parking zone to be agreed with LBG and operational with the provisions of 2,200 spaces, and the number of vehicles will be monitored for the two events; iv) beyond the first three months, survey two events annually (one every six months) as the periodic review; v) following each survey, if the service provision does not meet demand, the transport coordinator will work with TfL to improve the services accordingly.

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- **Management, marketing and communication** To ensure the delivery and management of the travel plan for the O2, the transport coordinator needs to promote and become an active member of the travel forum, actively encourage travel by non-car modes and provide appropriate up to date public transport travel information for visitors. This will be communicated via the O2 website and through all related publications. He also should ensure that car parking tickets are sold in advance with event tickets to prevent demand exceeding supply on event days.

MONITORING AND REVIEW

To ensure that non-car travel modes are accessible, easy to use and have sufficient capacity to accommodate all event types, regular monitoring and data collection is undertaken, and the initial travel plan targets are to be adapted when new survey data become available and travel patterns change.

The first two surveys are undertaken within the first three months of the O2 opening for the two events: i) Prince concert (PRINCE) Tuesday 7th August 2007 with18,264 tickets sold, and ii) NHL ice hockey (NHL) Saturday 29th September 2007 with 17,119 tickets are sold. The aim of the surveys is to determine the modal split of the visitors arriving and departing from the O2. A 10% sample of total attendees at the event is required. Tables 2 and 3 show the survey results, indicating the two-way mode split of the visitors to the O2.

Car		***Motorcycle***	***Taxi***	***Bus***	***Underground***	***Coach***	***Cycle***	***Walk***	***River***
Driver	***Passenger***								
8%	**12%**	**0.5%**	**2%**	**4%**	**67%**	**1%**	**<0.5%**	**<0.5%**	**4%**

Table 2 Prince concert visitor two-way mode split

Car		***Motorcycle***	***Taxi***	***Bus***	***Underground***	***Coach***	***Cycle***	***Walk***	***River***
Driver	***Passenger***								
9%	**15%**	**<1%**	**3%**	**5%**	**64%**	**2%**	**0%**	**1%**	**1%**

Table 3 NHL ice hockey visitor two-way mode split

Comparing with the target of 64% set out in the travel plan, the results have shown that AEG have been successful in promoting public transport to the O2 with 75% (PRINCE) and 70% (NHL) of visitors traveling to the venue by public transport,. In particular, the number of visitors traveling by the underground has been greater than expected (15% more in PRINCE and 12% more in NHL). This difference was mainly due to less people traveling by bus than expected. The lower bus use may be linked to the closure of the blackwall tunnel in the prince concert.

It might also imply that the survey did not capture a representative bus sample. According to the surveys, car use represents 24% of visitors traveled to NHL ice hockey which is slightly higher than the target of 22% and the prince concert (20%). However, the car park usage monitored on a monthly basis by the car park operator shows that the car usages is only 12% in the prince concert and 9% in the NHL ice hockey, suggesting a high number of car users within the sample obtained from the interviews. When the surveys are conducted, AEG purchase Thames Clippers who run the river Thames ferries, and buy six new jet boats to ferry visitors to and from the O2 to improve the service. According to the survey results, the initial target of 3% has been met in the prince concert with 4% of visitors traveling to and from the O2 by this mode, but not for the NHL ice hockey event.

CONCLUSION

The O2 has met its obligation to survey two different types of arena event within the first 3 months of the O2 opening. The survey results have shown that the venue is exceeding its travel plan targets. In particular, the promotion of the underground, bus and the new river service has been successful. The targets are achieved by effective promotions of using public transport and good communications between the O2 management team and its customers. The coordination between the O2, LBG and TfL play an important role in meeting the infrastructure targets and management of queues in public transportation services. The additional surveys are being conducted to improve the travel plan.

REFERENCES

Black, W.R. (1996) "Sustainable transportation: a US perspective", Journal of Transport Geography, Vol. 4, pp. 151–159.

European Commission (2001), "White paper, European transport policy for 2010: time to decide", Office for official publication of the European communities, Luxembourg.

Lidskog, R., Elander, I. and Brundin, P. (2003), "Towards sustainable urban transportation in the European union?", in Low, N. and Glesson, B. (Eds), Making urban transport sustainable, Palgrave Macmillan, Hampshire, pp. 223-39.

Loo, B.P.Y. (2002), "Role of stated preference methods in planning for sustainable urban transportation: state of practice and future prospects", Journal of the Urban Planning and Development, Vol.128 (4), pp. 210–224.

Steg L. and Gifford R. (2005), "Sustainable transportation and quality of life", Journal of Transport Geography, Vol.13, pp.59-69.

AEG (Anschutz Entertainment Group) (2006), "Anschutz Entertainment Group, the O2 travel plan" Transport Planning Practice, London, UK.

AEG (Anschutz Entertainment Group) (2007), "Anschutz Entertainment Group, the O2 Travel plan, monitoring report". Transport Planning Practice, London, UK.

EMPIRICAL STUDY ON THE DETERMINANTS OF ADOPTION OF GREEN PROCUREMENT IN MANUFACTURING SUPPLY CHAINS

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ABSTRACT

Purpose of this paper

The purpose of this study is to investigate the determinants of adoption of green procurement.

Design/methodology/approach

The relationship between the determinants and adoption of green procurement has been hypothesized. Based on the extant literature product performance, purchase price, the organization's environmental concerns, trading partners, and health and safety issues, are studied. Companies in the electronic industry that held ISO 14001 certification in Thailand before December 2004 were sampled for the empirical study. A survey was carried out with a sample of 150 companies in electronics industry. The empirical model then tested using regression analysis, to verify the hypothetical relationships of the study.

Findings

The results indicate that all of the hypothesized relationships were significantly supported in this study. Of the four variables, influence or pressure from the trading partners e.g., buyer's pressure on suppliers, was found to be the strongest predictor of the adoption of green procurement. This was followed by purchase price of products, product performance and the organization's commitment to environmental issues.

Research limitations/implications (if applicable)

The current was basically carried out within one particular country and within one industry. Hence, the findings are industry specific and indicative for other industries. But a wider study based on samples drawn from other industries and other manufacturing based economies may needs to be carried to understand the nature of the determinants of adoption of green procurement with the manufacturing supply chain.

Practical implications (if applicable)

This implies that, Original Equipment Manufacturing (OEM) and Original Designing and Manufacturing (ODM) companies in Thailand's electronic industry still have an opportunity to develop a competitive differentiation, if they adopted green procurement practices in response to the current wave of global environmental concern.

What is original/value of paper

This paper would enable understanding of the academic community as well as the practitioners who are trying to incorporate green supply chain or environmentally sustainable/responsible supply chains.

Key Words – Green supply chain, Environmental performance, and Green procurement

INTRODUCTION

With increasing awareness of environmental protection worldwide, the green trend towards conserving the Earth's resources and protecting the environment is overwhelming, exerting pressure on corporations in Thailand. The pressure accompanying globalization has prompted enterprises to improve their environmental performance (Zhu and Sarkis 2006). Consequently, corporations have shown growing concern for the environment. Increasing environmental concern has gradually become part of the overall institutional culture and, in turn, has helped to re-focus the strategies of corporations.

Global warming, reductions in air quality, pollution of waterways and widespread loss of biodiversity are but a few examples of the types of environmental impact that can be attributed to the coordinated activity of organizations in a supply chain. Much of this arises from manufacturing organizations that continue to produce large amounts of unnecessary waste or emissions rather than investing in better technologies or practices to prevent its generation at the source.

The "green" component to supply chain management involves addressing the influence of supply chain management on the natural environment. Motivated by an environmentally-conscious mindset, it can also stem from a competitive motive within organizations (Hervani et al. 2005).

The prime objective of this study is to understand the determinants of the adoption of green procurement by Thai electronic companies. That industry is dominated by OEM (original equipment manufacturing) and ODM (original designing and manufacturing) companies.

LITERATURE REVIEW

Description of Green Procurement Practices

Purchasers can improve the environmental performance of products and services by expressing environmental preferences through so called "green procurement". Environmental purchasing is defined as activities that include the reduction, reuse and recycling of materials in the process of purchasing. Procurement or purchasing decisions will have an impact on the green supply chain through the purchase of materials that are either recyclable or reusable, or have already been recycled (Sarkis 2003).

Green procurement is a solution for environmentally concerned and economically conservative business. It is the concept of acquiring a selection of products and services that minimizes environmental impact. It requires a company or organization to carry out an assessment of the environmental consequences of a product at all the various stages of its lifecycle. This means considering the costs of securing raw materials, and manufacturing, transporting, storing, handling, using and disposing of the product. "Green" products reduce waste, improve energy efficiency, limit toxic by-products, contain recycled content or are reusable.

With today's application of green procurement:

- Electronics industries comply with lead free protocols (WEEE) and Restriction of Hazardous Substances (RoHS) to minimize the hazard and toxicity of electronic parts.
- Furniture manufacturing industries change their strategy to comply with green concerns in the use of water-based finishes as an alternative to solvent-based ones.
- Toy manufacturers strictly control and follow ISO standards to limit the toxicity in toy components after news that large quantities of imported toys from China were banned form the US.
- Food industries used packaging made of natural materials, which is easier to discard or recycle.

Practicing green procurement demonstrates an organization's commitment to considering and minimizing the environmental consequences of its activities. Green supply is the buying organization's intent to improve the environmental performance of purchased input and/or of the suppliers that provide them. As such, green supply includes a wide variety of activities including cooperation between organizations to minimize the logistical impact of the material flows or information gathering regarding the purchased products' characteristics. Others have proposed definitions more focused on the purchasing function, suggesting that green supply activities consist of the involvement of the purchasing function in facilitating internally-driven environmental activities such as recycling, reuse and source reduction.

The practice of extending production goals from customers to their suppliers as a means to improve the overall performance of a supply chain has been a growing field of research for the past 15 years (Liker and Choi 2004). "Green supply," is a potentially effective mechanism for supply chain managers to improve the organization's record on corporate social responsibility, minimize risks to their reputation, reduce waste and increase flexibility in response to new environmental regulations (Melnyk et al. 2003).

Benefits of Green Procurement Include:

- Natural Conservation: Green products are generally produced in a manner that consumes less natural resources and energy or uses them more sustainably from the process of acquiring raw materials, processing and manufacturing parts, transporting and use, to final disposal.

- Waste reduction: Green products are generally designed with the intention of reducing the amount of waste created. For example, they may contain recycled material or use less packaging, and the supplier may operate a 'take-back' programme.

- Cost saving: Green products consist of natural materials, which can be recycled, reused and are easily disposed of. So an organization can achieve lower waste disposal costs, waste treatment costs and energy costs. In addition, green products generally require fewer resources to manufacture and operate, so savings can be made on energy, water, fuel and other natural resources.

- Decrease hazardous or toxic level: Green products produce lower levels of hazardous and toxic materials in the environment.

To reduce the environmental impact of the waste of electrical and electronic equipment (WEEE), the EU implemented the Waste Electrical and Electronic Equipment (WEEE) Directive in August 2005.

The literature on Green Supply Chain Management has been growing as organizations and researchers begin to realize that the management of environmental programmes and operations do not end at the boundaries of the organization. Overall, research in corporate environmental management and its operational relationships has been growing in recent years with a number of papers outlining these relationships.

Customer-supplier interactions and environmental performance

Programmes developed by business to "green" supplier activities or include environmental performance requirements in supply guidelines are increasingly evident in practice. Such initiatives are broadly referred to as either green-supply or green-supply-chain in both the academic and practitioner literature. Green supply has mainly included activities with suppliers such as:

- Programmes to reduce or eliminate materials used in manufacturing processes or products;
- Programmes focusing on the environmental compliance status and practices of supplier operations;
- Joint development of new materials, processes or other solutions to environmental issues (Sarkis 2003).

An earlier work found that customer firms that engaged in collaborative dialogue with suppliers were better able to understand the environmental impact of their supply chains. Studies have looked at customer-supplier relationships that were already characterized by improvement or learning activities: *". . . environmental improvements flow from ongoing joint efforts to improve productivity, eliminate defects and reduce costs, rather than from direct offers to transfer pollution prevention technology or organizational strategies designed expressly to eliminate toxins or prevent pollution"*.

CONCEPTUAL FRAMEWORK

The study reported in this paper analyzed the relationship between Green Supply Chain Management practices and factors such as environmental performance, financial performance and external stakeholders.

The independent variables included in the model were Product Performance, Purchase Price, the Organization's Environmental Consideration, and Trading Partners. The relationship of each of the independent variables on the dependent variable, the adoption green procurement, was examined. For each relationship, there is an assumed hypothesis, indicating that there is a positive relationship between each independent variable and the dependent variable.

Chien and Shih (2007) explained that environmental performance is defined as the environmental impact that the corporation's activity has on the natural milieu. Environmental performance indicators consists of OPI (operative performance indicators) and MPI (management performance indicators): OPI relate mainly to the consumption of materials, energy management, waste and emission production, and evaluation of real environmental aspects of organizations, whereas MPI are mainly concerned with the administration's efforts, measures, and contribution to the overall environmental management of the organization (Papadopoulos and Giama 2007).

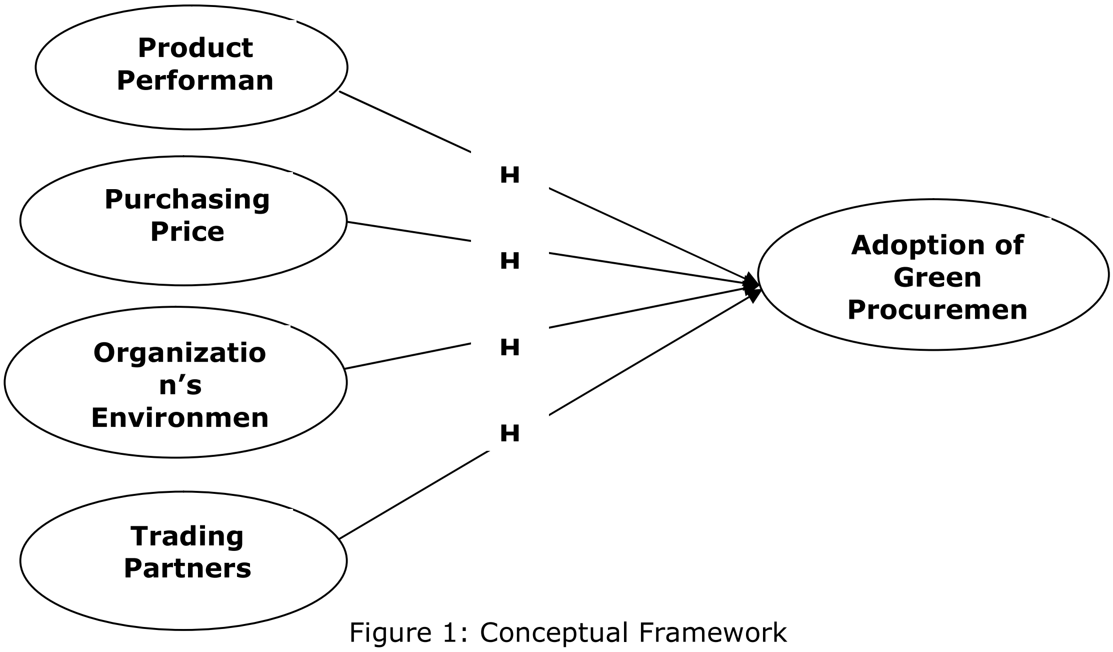

Figure 1: Conceptual Framework

OPI are considered to be part of the desired product performance, whereas MPI are classified as part of the organization's commitment to environmental issues. Adoption of green procurement can produce less waste and use more recycled material, thereby using energy, water and by-products in a more efficient way (Tsoulfas and Pappis 2006). Hence,

Hypothesis 1: Product Performance has a positive relationship with Green Procurement Adoption.

Adoption of Green Procurement can have a positive effect on a corporation's purchasing costs. This can cut the cost of materials purchasing and energy consumption, reduce the cost of waste treatment and discharge, and avoid fines in the case of environmental accidents (Zhu and Sarkis 2004). A sustainable approach can lead to internal cost saving, open new markets and find beneficial uses for waste (Tsoulfas and Pappis 2006). Financial performance is defined here as cost reduction, market share growth and profit increase. Environmental engagement has a positive effect on financial performance (for example, growth in profits, sales and market share) (Fuentes-Fuentes, *et al.*, 2004). Hence,

Hypothesis 2: Purchasing Cost has a positive relationship with Green Procurement Adoption.

There is a consensus in the literature that internal environmental management is a key to improving the performance of an enterprise. It is well known that senior managers' support is necessary and often a key driver for successful adoption and implementation of most innovations, technology, programmes and activities. To ensure environmental excellence, top management must be totally committed (Rice, 2003). A recent study reported that support from mid-level managers is also a key to successful implementation of EMS practices. A recent study used middle managers to find a positive relationship between middle managers' perceptions of corporate environmental pro-activity and environmental management. Hence,

Hypothesis 3: An Organization's Consideration of Environmental Issues has a positive relationship with Green Procurement Adoption.

A recent body of academic research supports the theory that the customer-supplier or supplier-supplier relationship may generate a positive pressure toward the adoption of green procurement (Klassen and Vachon 2003; Zhu and Sarkis 2004; Rao and Holt 2005). Communicating goals of sustainability or environmental performance through the supply relationship has resulted in, for example, collaborative waste reduction, environmentally sound innovation, cost-effective and environmentally beneficial solutions to production problems, and more rapid development and uptake of environmental technologies. There is growing empirical support for the role of the supply relationship in green procurement adoption.

A collaborative customer-supplier relationship has often led to the adoption of green procurement in both the customer and the supplier firm. Higher levels of customer and supplier interaction are likely to generate higher levels of green procurement adoption in the organization. A recent study identified key factors for environmental purchasing, such as providing design specifications to suppliers that include environmental requirements for purchased items, cooperation with suppliers for environmental objectives, environmental audit of supplier's internal management and suppliers' ISO14001 certification. Hence,

Hypothesis 4: Trading partners have a positive relationship with Green Procurement Adoption.

METHODOLOGY

Research design

This research used both primary and secondary data. Secondary data was derived from existing research, journals, case studies, and articles on the internet. Secondary data was used to understand what green procurement is, its applications in companies, and its benefits. The secondary data provided the idea of the framework to support the collection of primary data. Primary data was collected using questionnaires.

Sampling

Primary data collection requires proper sampling. Since the focus of the study is the Electronic Industry, the sample was drawn from electronic companies in Thailand that were ISO 14000 certified. These companies reported they had already adopted green procurement practices. The sample includes companies that export to overseas markets and/or provide raw materials or parts to manufacturing companies, which then produce parts and finished products for the European Union and North American markets.

Questionnaire Development

The data used in this research consist of questionnaire responses from customers and suppliers in the Thai electrical and electronic companies that have a profound impact on the environment. The questions were answered based on a five-point Likert-type scale (i.e. 1=least important, 2=less important, 3=important, 4=more important, 5=most important). Questionnaire items are listed in Table1.

The questionnaire focused on product performance, purchase price, the organization's environmental engagement and trading partners. Survey samples were selected randomly within the Thai electrical and electronic industry. The targeted companies were taken from the list of Benchmark Electronics (Thailand) supplier and customer directory as well as those that were ISO 14001 certified before the end of December 2004. A total of 150 questionnaires were sent out, and 137 valid responses were returned, a valid response rate of 90%.

Product Performance (0.702)[a]	**Mean[b]**	**S.D.**
Green procurement enables products to meet required performance with international standards.	4.09	0.716
Green procurement complicates the product performance measurement processes.	3.72	0.802
Design of products for reduced consumption of material/energy.	4.39	0.941
Design of products for reuse, recycling, recovery of material, component parts.	3.98	0.958
Design of products to avoid or reduce use of hazardous products and/or their manufacturing process.	4.14	0.806
Purchase Price (0.704)[a]	**Mean[c]**	**S.D.**
Green procurement causes higher cost of finished products due to R&D cost to reduce negative environmental impact.	4.08	0.795
Green procurement reduces waste cost due to the quality development of products and manufacturing process.	3.99	0.649
Green procurement brings higher purchasing cost but sales increase.	4.01	0.938
Green procurement makes purchasing cost of raw materials higher but other costs are lower.	3.97	0.813
Higher purchasing costs of raw materials impact Green procurement policy of the company.	4.1	0.843
Organization's Environmental Concern (0.714)[a]	**Mean[b]**	**S.D.**
Commitment of Green Supply Chain Management from senior managers	4.06	0.879
Support for Green Supply Chain Management from mid-level managers	3.81	1.103
ISO 14001 certification	4.37	0.87
Environmental management systems exist	4.39	0.646
Make a concerted effort to make every employee understand the importance of environmental management	4.42	0.703
Trading Partners (0.720)[a]	**Mean[b]**	**S.D.**
Mutual understanding on Green Supply Chain Management between supplier and company.	4.46	0.728
Mutual commitment on Green Supply Chain Management between supplier and company.	4.28	0.848
Capability to achieve mutual objective on Green Supply Chain Management.	4.1	1.009
Suppliers' ISO14000 certification.	4.28	0.795
Environmental audit of suppliers' internal management.	4.36	0.715

[a]Construct reliability (Cronbach's Alpha) shown in parentheses, [b] From 5 point scale (1 = Least Important and 5 = Most Important), [c] From 5 point scale (1 = Strongly Disagree and 5 = Strongly Agree)

Table 1: Summary of means and standard deviation of the scale items

ANALYSIS

The research findings in this study are reported in two parts. First, descriptive analysis is presented, and this is followed by inferential analysis. The descriptive analysis gives results as means and standard deviations. Inferential analysis is performed to test the hypothesized relationships between four independent variables and the adoption of green procurement.

Descriptive Statistics

Cronbach's Alpha was used to test the reliability of the scale items. All of the measurement scales met the scale reliability criteria suggested by Nunnally (1978). According to Cronbach (1951) if a value of the reliability estimate is 0.70 or over, it can be assumed that the instrument is reliable. Table 1 shows the descriptive statistics, including Cronbach Alpha, mean and standard deviation for each variable.

Inferential Analysis

From the research hypotheses described in the previous section, it was assumed that all four independent variables had a positive relationship with the adoption of green procurement for green supply chain management. Multiple regressions were used as a tool to determine the level of this relationship (Tables 2 and 3).

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.855(a)	.732	.723	.082	1.468

a Predictors: (Constant), Trading Partners, Purchase Price, Product Performance, Organization's Environmental Commitment. b Dependent Variable: Green Procurement

Table 2: Multiple Regression Model Summary(b)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.346	4	.587	86.628	.000(a)
Residual	.860	127	.007		
Total	3.206	131			

a Predictors: (Constant), Trading Partners, Purchase Price, Product Performance, Organization's Environmental Commitment. b Dependent Variable: Green Procurement

Table 3: Multiple Regression ANOVA(b)

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	1.908	.090		21.233	.000		
Product Performance	.095	.013	.351	7.506	.000	.965	1.036
Purchase Price	.107	.013	.380	8.194	.000	.983	1.018
Organization's Environmental Commitment	.093	.013	.348	7.260	.000	.920	1.087
Trading Partners	.106	.013	.388	8.037	.000	.908	1.102

a Dependent Variable: Green Procurement

Table 4: Multiple Regression Coefficients(a)

From the results for the correlation coefficients in Table 5, all the independent variables have a statistically significant relationship (with a probability of 0.00 which is less than 0.05 desired to accept the hypothesis) with the adoption of green procurement. Therefore, the null hypothesis is rejected and it is accepted that there is a relationship between each independent variable and green procurement adoption. The correlation coefficient (R) indicates the strength and significance of the relationship between variables. This means that the five variables have a strong positive relationship with the dependent variables. The coefficient of determination (R Squared) is = 0.732, which means that about 73.2% of the variance in the dependent variable, namely green procurement adoption, can be appropriately explained by these independent variables, which are Product Performance, Purchase Price, the Organization's Environmental Commitment and Trading Partners.

	Green Procurement	**Product Performance**	**Purchasing Price**	**Organization's Environmental Commitment**	**Trading Partners**
Green Procurement Adoption	1	.458(**)	.451(**)	.525(**)	.560(**)
		.000	.000	.000	.000
Product Performance	.458(**)	1	.021	.088	.164
	.000		.810	.308	.056
Purchasing Price	.451(**)	.021	1	.136	.053
	.000	.810		.118	.544
Organization's Environmental Concern	.525(**)	.088	.136	1	.249(**)
	.000	.308	.118		.003
Trading Partners	.560(**)	.164	.053	.249(**)	1
	.000	.056	.544	.003	

** Correlation is significant at the 0.01 level.

Table 5: Correlations

FINDINGS

From the study, it was found that, in response to the external pressures and globalization, Thai electronics companies are required to comply with the concept of green procurement. The four independent variables can predict the tendency towards green procurement adoption for successful Green Supply Chain Management, meaning that whether the management do or do not adopt green procurement practices depends on product performance, purchase price, organizational environmental commitment and trading partners.

In relation to conducting successful green procurement, the collaboration of suppliers is essential. Thai electronics companies perceive that successful environmental performance requires suppliers to understand green procurement and environmental policies. An environmentally friendly response is an important management resource. Thai firms must integrate environmental initiatives into their corporate management since they can lead to increased business, improved business performance, and further enhancement of their credibility with outside parties.

This paper provides a basis for understanding more about green procurement and indicates that Thai companies, especially in the electronics industry, must realize the importance of green procurement in order to build their competitive advantage over competitors in both domestic and international contexts.

REFERENCES

Chien, M. K. and Shih, L. H. (2007), "An Empirical Study of the Implementation of Green Supply Chain Management Practices in the Electrical and Electronic Industry and their Relation to Organizational Performances," International Journal of Environmental Science and Technology, Vol.4, No. 3, pp. 383-394.

Fuentes-Fuentes, M. M.; Albacete-Saez, C.A. and Llorens-Montes, F.J. (2004), "The Impact of Environmental Characteristics on TQM Principles and Organizational Performance," International Journal of Management Science, 32, pp. 425-442.

Klassen, R. and Vachon, S. (2003), "Collaboration and Evaluation in the Supply Chain: The Impact on Plant-Level Environmental Investment," Production and Operations Management, Vol. 12 No. 3, pp. 336-52.

Liker, J. and Choi, T. (2004), "Building Deep Supplier Relationships," Harvard Business Review, December.

Melnyk, S.; Sroufe, R. and Calantone, R. (2003), "Assessing the impact of environmental management systems on corporate and environmental performance," Journal of Operations Management, Vol. 21, No. 3, pp. 329-51.

Nunnally, J. C. and Bernstein, I.H. (1994), Psychometric Theory, McGraw-Hill, Inc., NY.

Papadopoulos, A.M. and Giama, E. (2007), "Environmental performance evaluation of thermal insulation materials and its impact on the building," Building and Environment, 42, pp. 2178-2187.

Rao, P. and Holt, D. (2007), "Do green supply chains lead to competitiveness and economic performance?" International Journal of Operations & Production Management, Vol. 25 Nos 9/10, pp. 898-916.

Sarkis, J. (2003), "A strategic decision framework for green supply chain management," Journal of Cleaner Production, Vol. 11 No. 4, pp. 397-409.

Tsoulfas, G.T. and Pappis, C.P. (2006), "Environmental principles applicable to supply chains design and operation," Journal of Cleaner Production, 14, pp. 1593-1602.

Zhu, Q. and Sarkis, J. (2006), "An inter-sectoral comparison of green supply chain management in China: Drivers and practices," Journal of Cleaner Production, 14, pp. 472-486

Zhu, Q. and Sarkis, J. (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises," Journal of Operations Management, Vol. 22 No. 3, pp. 265-89.

Hervani, A. A.; Helms, M. M. and Sarkis, J. (2005), "Performance measurement for green supply chain management," Benchmarking: An International Journal, Volume: 12, Issue: 4, pp. 335.

LIFE CYCLE ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF LOGISTICS

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1. INTRODUCTION

Many corporations are beginning to recognize the importance of addressing environmental issues, and have begun examining ways to reduce the environmental impact of the products which they handle. Since the latter 1990s, companies have been using a concept known as Life Cycle Assessment (LCA) to understand the overall impact of a product over the course of its product lifecycle, and seek ways to reduce that impact. LCA not only considers the environmental impact involved in manufacturing a product, but every other activity related to its production and use, as well, including the extraction of raw materials, logistics (distribution) and sale, actual use, disposal and recycling of the materials. After considering the impact at all of these stages, efforts can be made to reduce the impact holistically.

In addition to the advances in LCA, there has also been an increase in the availability of information about the environmental impact of products, as well as rising awareness among consumers and ways for them to obtain information, such as "Eco"-labeling. Recently there has been a growing interest in the "carbon footprint" of products, and companies are trying to set standards for calculating this information (1).

When considering the environmental impact of a product over its entire lifecycle, one important element that must be included is the transport and storage of the product from the time it leaves the factory until it reaches the final consumer's home or office. During this logistics stage, the environmental impact of transporting the items by truck is particularly important. Therefore, it is becoming ever more important to seek ways to reduce environmental impact at the logistics stage.

In Japan, the Japan Environmental Management Association for Industry (hereafter, "JEMAI") has introduced the "Eco-leaf Environmental Label" as a way to inform consumers about the environmental impact of products, particularly for manufactured goods. Since 2002, JEMAI has been collecting and publicizing quantifiable data on the environmental impact of products over their full lifecycle, particularly the amount of greenhouse gases generated. The "Eco-leaf Environmental Label" system assigns each product to a particular category, using the "Product Category Rule", then uses quantified data on the environmental impact of each product to set a standard for each category.
We have analyzed the quantitative data obtained via the "Eco-leaf Environmental Label" system, which covers the environmental impact of products over their entire lifecycle, and examined the economic impact generated at the logistics level.

In this paper, we will consider the influence of logistics activities on a product's environmental impact over the course of its lifecycle, and particularly the greenhouse gas emissions generated during the logistics stage, for each category of product. We will also seek to quantify the degree of impact that logistics activities have, as a percentage of the total LCA environmental impact, with the aim of demonstrating the importance of logistics issues in a product's overall lifecycle.

As of December 2009, there were 48 individual categories of product and services in the "Eco-leaf Environmental Label" system to which actual products had been assigned. Excluding those items for which there was no quantifiable logistics stage, or no concrete "product", 42 of these categories have been selected for consideration in this report.

2. OVERVIEW OF ENVIRONMENTAL LABELING, AND THE "ECO-LEAF ENVIRONMENTAL LABEL"

A. Environmental Labeling, and the "Eco-leaf Environmental Label"

Table 1 provides a summary of the three main types of environmental labeling. The first category, (Type I) consists of labeling standards developed by third-party groups, which set standards for each category of products and then try to calculate whether or not each product meets these standards. Products that do meet the standards set by the group are permitted to use the group's mark on their product labels. The second category (Type II) includes label marks developed by individual manufacturers, as a way of indicating their commitment to protecting the environment. The third category (Type III), which includes the "Eco-leaf Environmental Label" adopts a total LCA standard, seeking data on the impact of every stage in the product's lifecycle from raw materials production, production and logistics to sale, use, disposal and recycling. This data must be quantified and publicized by all companies who use the mark on their label, though there is no "passing" or "failing" standard set to decide which products can or cannot use the mark on the labels.

Table 1. Types of Environmental Labeling

ISO classification	Summary	Characteristics	Examples
Type I (ISO14024)	Certification that a given product is above standard level	・Decide if a product "pass" or "fail" the standard ・Classification of products and passing standard are created by third party organizations ・Examination to grant permission to use "mark" is performed for each request by a manufacturer	Eco Mark (Japan) Blue Angel (Germany) Nordic Swan (Nordic countries)
Type II (ISO14021)	Declaration of commitment to protecting the environment by a manufacturer	・Manufacturer individually claims their commitment to improve the environmental impact of their products ・Manufacturer uses the "mark" for advertising the product ・No third party organization is involved to verify the contents of the claim of manufacturer	Individual manufacturer
Type III (ISO14025)	Disclosure of quantitative environmental impact data	・No judge is given if a product "passes" or "fails" certain standard ・Quantitative data on environmental impact is disclosed ・It is up to consumer how to interpret the data	EcoLeaf (Japan) EPD (Sweden) EDP (Korea) EDPS (Canada)

Source: Japan Environmental Management Association for Industry, "Eco-leaf Environmental Label"

B. Life Cycle Stages Considered by the "Eco-leaf Environmental Label"

For the purposes of this labeling standard, a product's lifecycle is divided into four stages: production, logistics(distribution), use, and disposal. The activities that are included in each of these stages are defined under the Product Category Rule for each product. A general summary is provided below.

(1) Production Stage

This category includes raw materials extraction, the production stage for manufactured materials such as steel, aluminium and plastic, the processing of these raw materials, the production of components, the sub-assembly of structural units, and the final assembly of all structural units into a finished product.

(2) Logistics (Distribution) Stage

This stage includes every step of the journey from the place where the product was manufactured to the place where it will be used by the final consumer. The exact scope of "transportation", and the transportation method, is defined for each product in the Product Category Rule. The environmental impact of transportation and storage varies depending upon the characteristics of the product, and it may also vary depending on the individual manufacturer, who may have in-house logistics facilities or may use a logistics contractor to provide direct delivery, making it relatively easy to calculate the

environmental impact, or may rely on wholesalers, retailers or transport companies, in which case it can become quite difficult to quantify the environmental impact.
For domestic transportation, most categories of product derive their data using a model which employs the average figures for all companies using a given transportation method and load ratio. In addition, the Product Category Rule for many products specifies the total transport distance. Of the 42 product categories we deal with in this report, 22 categories had an average transport distance of 500km, 8 categories had a transport distance of 100km, 5 categories had an average 300km transport distance, and there was one category each for transport distances of 10km, 200km and 400km. The final three categories had no transport distance specified in the Product Category Rule. Data on products shipped to Japan from overseas is set separately by each company for any product that applies. Transportation of the products or materials during the product use and disposal stages is included in the environmental impact calculations for those stages.

(3) Product Use Stage

This stage includes items such as the electric power consumption of the product during use/standby, any fuel consumed during the product's operation, as well as the environmental impact of producing, transporting and disposing of any spare parts or consumable items that are required to operate the product.

(4) Disposal Stage

This stage covers all activities that are involved in the disposal of a product after its use, including the collection and transport of the used product, disassembly or dismantling, separation of components and materials, incineration, treatment to eliminate toxic substances, and final burying or processing and recycling of the materials to prepare them for reuse.

In this paper, we will adopt a slightly different categorization, separating the product lifecycle into six stages: raw materials production, final product manufacturing, logistics, use, disposal, and recycling.

3. CURRENT GLOBAL WARMING IMPACT, AS ASSESSED BY LCA

A. Global Warming Impact over a Product's Entire Lifecycle

If we convert energy use for the entire supply chain to CO_2 equivalents (excluding the portion for recycling), we can determine the global warming impact for the product. The largest share of products are those with a weight of 10-99kg(28.6% of all product categories), while 23.8% have a weight of 100-999kg, 16.7% weigh between 1-9kg, and 16.7% weigh over 1000kg. A majority of electronics products fall into the 100-999kg category, and machinery products also are bulky, and have a fairly high environmental impact. The Other Products and Other Services categories, on the other hand, generally are in the 1-9kg or the under 1kg categories, and have a smaller environmental impact. To calculate the global warming impact for each category, it is necessary to use the weighted average of each product in the category to calculate an average.

The product category with the largest environmental impact is "Large-Scale Machinery" – a category that includes low-voltage inverter boards, which generate an average of 96,426kg of CO_2 over their full lifecycle, and plant control panels (water treatment) which produce 12,209kg of CO_2. These large and bulky pieces of machinery have a very large environmental impact. Metal water heating systems also have quite a large impact, generating 7,421kg of CO_2, metal-enclosed switch gears (high-voltage panels) generate an average of 5,034kg of CO_2, and cigarette and soft drink vending machines generate an average of 4,374kg. Although metal water heating systems tend to be relatively compact by comparison to their weight, and thus have a less significant environmental impact in logistics, these products consume a lot of energy in heating water from around 15C (average) to 40C. Thus, their environmental impact during the "Product Use" stage is very large. By contrast, product categories with a relatively low environmental impact include cardboard drink cartons (0.09kg of CO_2), food and beverage cans (0.14kg), hook-and-loop fasteners (0.30kg) and power/telecommunications cables (0.32kg).

B. Determining Environmental Impact at Each Stage

If we calculate the degree of environmental impact at each stage of the product lifecycle, an average calculation for all product categories shows that 40.3% of the environmental impact occurs during the product use stage. Raw materials production and materials production also accounts for a large share, at 37.1%, while manufacturing accounts for 16.6%. By comparison, the logistics stage accounts for a relatively small share – just 2.2% – and product disposal contributes just 3.8%. Although a large portion of a product's environmental impact is created during production, these figures show that it is the product use stage which accounts for the largest share. These averages, however, do not tell the whole story. There is a large variation in these percentages depending on the category of product. Furthermore, if the environmental impact for the supply chain is considered to be 100%, recycling the materials after use can reclaim 17.9% of this impact (by reducing the greenhouse gases generated by products made with the recycled materials). Figure 1 shows a breakdown of a product's environmental impact at each stage of the lifecycle. For our purposes, the stage we are most interested in examining is the logistics stage, which accounts for a low 2.2% of the total lifecycle impact.

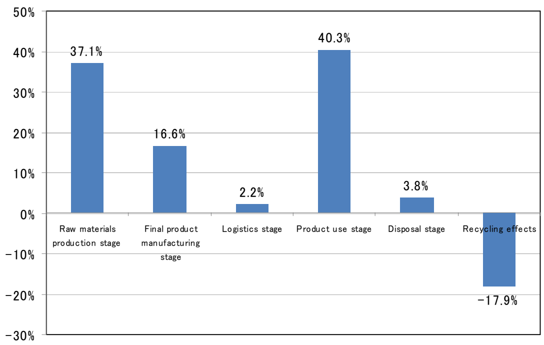

Figure 1. Average share of total environmental impact at each stage of the product lifecycle

Of the product categories we examined, 28.6% generate the majority of their environmental impact (over 50%) at the raw materials extraction and materials production stage. Another 21.4% of the categories generate between 20% and 50% of their environmental impact at this stage. However, the majority of product categories that fall into the services and construction materials group [(2)] generate more than half of their total environmental impact at the raw materials extraction stage. Turning to the manufacturing stage, 45.2% of the categories generate less than 10% of their environmental impact during manufacturing. In particular, many types of machinery and electronics products generate less than 10% of their total impact at the manufacturing stage. Though these items may generate a large amount of CO_2 during manufacturing, the largest share of their environmental impact actually comes during the product use stage. The logistics stage accounts for a relatively small share of the total environmental impact, particularly compared to the impact of raw materials extraction, materials production, manufacturing and use. There is a wide disparity in the degree of environmental impact created during the product use stage. Over half of the product categories generate more than 50% of their overall environmental impact at this stage, but another 35.7% of product categories generate less than 10% of their impact during this stage. Among the products that have a large environmental impact during product use, electronics products and machinery are heavily represented. On the other hand, basic materials, components, other products and services generate less than 10% of their total environmental impact during the product use stage. The disposal stage, like logistics, accounts for a comparatively small share of total environmental impact, on average. For 26.2% of all product categories, the disposal stage accounts for 2-5% of total lifecycle impact, 21.4% of product categories generate between 1% and 2% of their impact during this stage, and another 21.4% generate less than 0.5% of total environmental impact during the disposal stage.

4. CURRENT LEVELS OF ENVIRONMENTAL IMPACT AT THE LOGISTICS STAGE

A. Global Warming Impact at the Logistics Stage

If we convert the logistics activities related to each product into carbon equivalents, and express their environmental impact in terms of kilograms of CO_2, 28.6% of all product categories generate between 0.1kg and 0.5kg of CO_2 during the logistics stage, while another 19.0% of the categories generate less than 0.1kg of CO_2. In other words, nearly half (47.6%) of products generate less than 0.5kg at the logistics stage. On the other hand, 19.0% of products have an environmental impact during logistics that corresponds to over 10kg of CO_2.

Table 2. Global warming impact created at the logistics stage, for major product groups

Major Categories	-0.1kg	0.1-0.5kg	0.5-1kg	1-2kg	2-10kg	10kg-	Total
Electronics Products		3		5	4	4	16
	0.0%	18.8%	0.0%	31.3%	25.0%	25.0%	100.0%
Machinery	1	1				4	6
	16.7%	16.7%	0.0%	0.0%	0.0%	66.7%	100.0%
Materials and Components					1		1
	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Construction Materials	2	7	1		2		12
	16.7%	58.3%	8.3%	0.0%	16.7%	0.0%	100.0%
Other Products	2	1					3
	66.7%	33.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Services	3		1				4
	75.0%	0.0%	25.0%	0.0%	0.0%	0.0%	100.0%
Total	8	12	2	5	7	8	42
	19.0%	28.6%	4.8%	11.9%	16.7%	19.0%	100.0%

Some 75% of products in the construction materials segment, 100% of products in the “other products” segment and 75% of products in the “services” segment generate less than 0.5kg of CO_2 during the logistics stage (“0.1kg-0.5kg” or “less than 0.1kg”). On the other hand 66.7% of all products in the machinery segment generate over 10kg of CO_2 during logistics, and 31.3% of products in the electronics segment generate over 1kg of CO_2.

The product category with the largest environmental impact during logistics is “metal-enclosed switch gears (high-voltage panels)”, which generate 54.6kg of CO_2 during logistics. This is followed by the “plant control panels (water treatment)” category, at 35.0kg, low-voltage inverter boards, at 31.4kg, “low-voltage motorized control centers”, at 25.0kg, and “cigarette and soft drink vending machines”, at 23.2kg of CO_2. The lowest figures are for “hook-and-loop fasteners” (0.003kg) and food & beverage cans (0.008kg). The logistics stage accounts for a much lower share of total global warming impact than materials production, manufacturing and product use. Indeed, 33.3% of all products generate between 0.5% and 1.0% of their total environmental impact during the logistics stage, 19.0% of products generate less than 0.5%, and another 19.0% generate between 1.0% and 2.0% of their total impact during this stage. In the services category the share is over 10% and for construction materials, it is between 2% and 5%; however, it is less than 0.5% for most products in the machinery category as a whole, and between 0.5% and 1.0% for the electronics category. Cardboard drink containers have the highest percentage – 15% of their total environmental impact is generated during logistics – while packing materials have 13.2% of their impact during logistics. Other products with high percentages include rainwater collection tank materials (8.2%), electronic blackboards (5.5%), and food & beverage cans (5.4%). These products are characterized by relatively low levels of environmental impact during the “product use” stage, but being comparatively bulky, as is true of containers and packing materials. By contrast, items that have a very large environmental impact during the product use stage tend to have low contributions from the logistics stage. This is true of metal water heating systems (0.002%), low-voltage inverter boards (0.03%), digital printers (0.14%) and POS terminals (0.17%).

Table 3. Share of global warming impact at the logistics stage, for major product groups

Major Categories	-0.5%	0.5-1%	1-2%	2-5%	5-10%	10%-	Total
Electronics Products	4	6	4	1	1		16
	25.0%	37.5%	25.0%	6.3%	6.3%	0.0%	100.0%
Machinery	3	2	1				6
	50.0%	33.3%	16.7%	0.0%	0.0%	0.0%	100.0%
Materials and Components					1		1
	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Construction Materials	1	4	2	5			12
	8.3%	33.3%	16.7%	41.7%	0.0%	0.0%	100.0%
Other Products		1	1	1			3
	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	100.0%
Services		1			1	2	4
	0.0%	25.0%	0.0%	0.0%	25.0%	50.0%	100.0%
Total	8	14	8	7	3	2	42
	19.0%	33.3%	19.0%	16.7%	7.1%	4.8%	100.0%

B. Relationship of the Logistics Stage to Other Stages

The relationship of environmental impact at each stage of the lifecycle shows a relatively high degree of correlation between stages. In particular, there is a high correlation between the impact at the manufacturing stage and that at the logistics stage, with a 0.930 correlation coefficient (p value= 5.41E-16), between the raw materials production and manufacturing stage, with a 0.908 correlation (p value = 1.07E-16), and between the logistics stage and raw materials production stage, at 0.897 (p value = 9.16E-16). The product use stage has a somewhat large correlation to the raw materials production stage, with a coefficient of 0.602 (p value = 2.47E-05), but very weak correlation to the other stages. This correlation can probably be explained by the relationship of size and weight to the product's impact on the environment. Bulky items like machinery require large volumes of raw materials, and are large and heavy to transport. Conversely items like fasteners, beverage and food cans, and cardboard drink containers are small, consume few materials and are relatively easy to transport. The size and weight of the items affects their environmental impact at the raw materials extraction and production stages, as well as the logistics stage.

Table 4. Correlation coefficient between environmental impact at each stage of the lifecycle

	raw materials production stage	fianl product manufacturing	logistics stage	product use stage	disposal stage
raw materials production stage	1.000	0.908	0.897	0.602	0.738
fianl product manufacturing stage	0.908	1.000	0.930	0.383	0.760
logistics stage	0.897	0.930	1.000	0.412	0.711
product use stage	0.602	0.383	0.412	1.000	0.028
disposal stage	0.738	0.760	0.711	0.028	1.000

C. Environmental Impact as a Function of Weight

At the logistics stage, there is a strong correlation between environmental impact and the weight of the product (including the weight of any packaging materials). This relationship has a coefficient of 0.901 (p value = 4.64E-16). The logistics of data points for this relationship is shown in Figure 2. There is a similarly strong relationship between product weight and the environmental impact at the raw materials production stage (coefficient =0.982, p value =1.56E-30) and at the manufacturing stage (coefficient =0.902, p value =3.48E-16). Clearly, the weight of a product has an important influence on its environmental impact at every stage of the lifecycle.

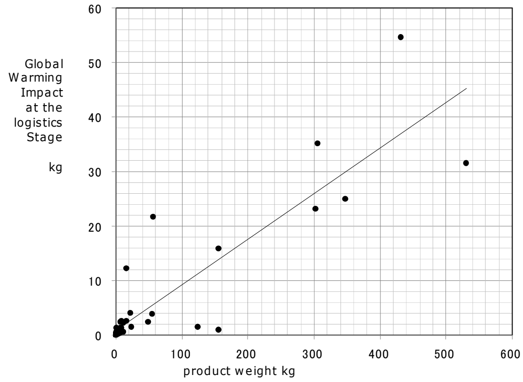

Figure 2. Relationship of product weight to environmental impact at the logistics stage

If we divide the weight of greenhouse gases generated at each lifecycle stage (kg-CO_2) by the weight of the product, we derive figures that show us the environmental impact of the product per unit of weight. We note that the relationship between the "per-kg" impact at the manufacturing stage has a fairly strong relationship to the "per-kg" impact at the disposal stage (coefficient =0.568, p value =8.62E-05), but there is only a weak relationship between the comparable figures at the logistics stage and the raw materials production stage (coefficient =0.405, p value =0.0079) and between the logistics stage and the disposal stage (coefficient =0.398, p value =0.0091). Other stages have virtually no significant correlation.

Table 5. Correlation coefficient between stages in terms of the Environmental impact per unit of weight (CO_2-kg/kg)

	raw materials production stage	final product manufacturing stage	logistics stage	product use stage	disposal stage
raw materials production stage	1.000	0.368	0.405	-0.082	0.274
final product manufacturing stage	0.368	1.000	0.201	0.011	0.568
logistics stage	0.405	0.201	1.000	-0.039	0.398
product use stage	-0.082	0.011	-0.039	1.000	0.005
disposal stage	0.274	0.568	0.398	0.005	1.000

D. Characteristics of Environmental Impact at the Logistics Stage for Each Product Category

In Table 6, we present a comparison of the individual product categories in terms of their "per-kg" environmental impact at the logistics stage. The total environmental impact at the logistics stage is shown on the horizontal axis and the per-kg impact is shown on the vertical axis. Items in the top right area of the graph are products that not only have a large environmental impact at the logistics stage, but also have a high impact per unit of weight. Many electronics products are concentrated in this area, suggesting that these products are a particular environmental concern. Items in the lower left area have both a low overall environmental impact and a low impact per unit of weight. This region of the graph includes a large number of construction material, and the conclusion we can draw is that their environmental impact is less of a concern. Items at the top left have a low overall impact on the environment, but their impact per unit of weight is high. Various types of containers and packing materials are found in this area of the graph, suggesting that logistics of these items is inefficient.

Table 6. Environmental impact of each product category, at the logistics level

		Global warming impact at the distribution stage	
		less than 1kg	more than 1kg
Global warmin gl impact as a function of weight (CO2-kg/kg)	more than 0.1	cardboard drink container mobile printer intercom fixed-line telephone network camera bevarage and food cans plastic folder made from resin pellet small photo printer packing materials hook-and-loop fastener water meter	power line communication modem and module PBX system electric blackboard deta projector heated toilet with bidet FAX EP/Inkjet printer flat bed scanner/sheet fed scanner thermal card printer personal computer and display monitor for PC metal-enclosed switch gear (high voltagepanel) plant control panels (water treatment) electrastatic drum type photocopier digital printers
	less than 0.1	metal water heating systems lithography presisitized plate (including CTP) vinyl floor tile (homogenious) power/telecommunications cables industrial chains tile carpets propane gas meter with microcomputer digital camera free access floor water meter box foamed polystyrene	cigarette and soft drink vending machine low-voltage motor control center rain water tank materials low-voltage inverter boards POS terminals toilet bowl

6. CONCLUSION

In this paper, we have analyzed the quantitative data obtained via the "Eco-leaf Environmental Label" system, which covers the environmental impact of products over their entire lifecycle, and examined the economic impact generated at the logistics level. If we look at overall averages for environmental impact at each stage of the lifecycle, it is apparent that logistics accounts for just 2.2% of the total lifecycle impact – a very low percentage, particularly in comparison to the raw materials production stage and the product use stage.

Examining the environmental impact at the logistics level more closely, when converted to CO_2 equivalents, we note that just less than half of all product categories (47.6%) generate 0.5kg of CO_2 or less during logistics. Construction materials and other products are heavily represented in this group. On the other hand, 19.0% of the product categories generate 10kg of CO_2 or more during the logistics stage, and many types of machinery fall into this group. A majority of electronics products generate between 1kg of CO_2 or more during logistics, and these product categories contribute a large share of the logistics industry's overall environmental impact. We noted that a product's weight has a very high correlation to the amount of CO_2 generated at the logistics stage, and when we analyzed the CO_2 generated per unit of product weight, it became clear that electronics products tend to have a relatively high impact on the environment. Thus, an important issue to address is how to reduce the environmental impact of distributing electronics products.

In the process of making LCA, it has been difficult to obtain good quantitative data on the impact at the logistics stage. This issue has not been studied much, in the past. In this paper, we have provided quantitative information to clarify the environmental impact of logistics activities, and its relative importance compared with the impact at other stages of the product lifecycle. There are major disparities in the logistics impact of different products, both in terms of the absolute impact on the environment, and the share of total-life-cycle environmental impact. This paper seeks to identify those products for which logistics has a particularly large impact, relative to the total-life-cycle environmental impact for the product. These products should be a particular target in trying to address the environmental impact of logistics activities. Going forward, in order to examine ways to reduce the environmental impact of products over their lifecycle, and at the logistics stage in particular, it will be very important to clarify the relationship between logistics and LCA.

NOTES:

(1) Manufacturers that use the "Eco-Leaf Environmental Label" on their products are required to obtain specific quantitative data on the environmental impact of their products (greenhouse gas generation, oxidation, ozone depletion, impact on water quality, energy consumption, natural resource depletion and other effects on the environment) and publicize the data on the Internet. Most of the products covered by this label are manufactured goods. The only data used to determine the product's "carbon footprint" is that related to the generation of greenhouse gases. This environmental impact is directly shown on the product. Food products and daily use items predominate.

(2) The individual product categories are grouped into five major groups – Electronics Products (home appliances, information equipment and office equipment), Machinery (automobiles, transport equipment, production machinery and precision instruments), Materials and Components (steel, non-ferrous metals, plastic, glass, cement, and items made of these materials), Construction Materials (materials for construction, civil engineering and housing construction) and Other Products (daily use items, stationery and office supplies, etc.).

REFERENCES:

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.

ECOLOGICAL IMPACTS OF AUTONOMOUSLY CO-OPERATING TECHNOLOGIES IN INTERNATIONAL SUPPLY NETWORKS – A MODEL FOR ANALYZING CO2-EFFECTS BY IMPLEMENTING INTELLIGENT CONTAINERS IN FRUIT LOGISTICS

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INTRODUCTION

Corresponding to an increasing awareness of global warming the concept of Green Logistics gains more and more relevance for Logistics Service Providers (LSP) (New 2004). Furthermore, cool chain logistics, especially for fresh fruit needs careful planning in order to avoid unnecessary CO_2 emissions. These accelerating environmental requirements add to the existing wide spectrum of "traditional" challenges (e.g. due time reliability, demanded decrease of total production time and costs) in International Supply Networks (ISN) (Klaus & Kille 2006) that confronts LSP with a highly complex and diversified set of requirements also concerning the field of fruit logistics.

Modern smart technologies (e.g. RFID) might promise an approach to deal with this additional complexity. Those technologies enable a decentralized information acquisition, processing, and decision-making, which is based on the idea of Autonomous Cooperation (AC) (Hülsmann & Windt 2007). One example for applying the idea of AC to logistics is the prospective implementation of a so-called "Intelligent Container" (IC) in fruit logistics (Jedermann & Lang 2009). Due to the smart features of an IC a respective ISN consisting of a large amount of heterogeneous and interacting ICs might exhibit the same characteristics and outcomes as a Complex Adaptive System. Therefore, from a complexity science-based perspective, such an ISN can be regarded as a "Complex Adaptive Logistics System" (CALS). CALS comprise heterogeneous agents that are autonomous, interactive, and able to learn, which leads to self-organization co-evolution and emergence of the whole system (Wycisk, McKelvey & Hülsmann 2008). According to Hülsmann & Windt (2007) the smart features (e.g. self-controlling sensor networks) produce and process more goal-oriented information in a shorter time directly at the place of action than in a centralized logistics system (Hülsmann & Windt 2007). Hence, it is assumable that suchlike characteristics and the resulting outcomes might have impacts on the ecological footprint of logistics systems. Consequently, the following question arises: How can the assumable effects, in terms of contributions and limitations of smart, autonomously co-operating technologies, on the ecological footprint of an ISN be verified?

Therefore, using the example of implementing the IC in fruit logistics networks, the paper's goal is to develop a structural equation model that reflects hypotheses about the existence of causal relationships between the visionary implementation of the IC in fruit logistics and its effects on the emission of CO_2. Therefore, the paper aims to provide a characterisation of ISN in fruit logistics as CALS in order to establish a theoretical framework for the model development. Furthermore, the paper intends to develop hypotheses about the existence of causal interrelations between a CALS, based on the smart features of an IC (e.g. the self-controlling sensor network), and the network's CO_2-

emissions. These causal assumptions shall be integrated in a conceptual structural equation model that shall serve as a basis for further research and which will be discussed critically regarding its contributions and limitations.

The paper will be structured as followed: The second section will provide a description of the characteristics of the given case in fruit logistics. Additionally, the autonomously controlling and co-operating features of an IC will be presented. This also comprises a classification of IC using logistics systems as CALS. The third section is dedicated to identify variables and causal interrelations between the smart characteristics of an IC and CO_2-emissions as a theoretically profound basis for a further measurement of environmental effects. In the fourth section possible contributions and limitations of the developed model to verify assumed environmental impacts of the ICs-network will be discussed. In the fifth, the paper will conclude with the results and implications for future research.

REALISING THE VISION OF COMPLEX ADAPTIVE LOGISTICS SYSTEMS VIA INTELLIGENT CONTAINERS IN FRUIT LOGISTICS

The planning of the transportation of fresh fruit in the field of cool chain logistics tries to avoid unnecessary CO_2 emissions that are not only due to the length of the transport routes and the required energy for cooling but mainly due to the amount of waste. Depending on the type of fruit, up to 30% of the transported food products do not arrive at the final customer in proper quality state (Scheer 2006). Besides the direct financial loss, this is also an environmental problem. Moreover, all energy that has been spent for growing, cooling and transport is lost. In case of a fixed commitment, a replacement delivery has to be organised with a poor CO_2 footprint caused by low utilization of capacity or necessary air- instead of road- or sea transport. Hence, fresh fruits have a natural loss of quality or shelf life over time. The main causes for reduced shelf life or complete decay are temperature deviations from the recommended transport conditions. In order to deal with these challenges several models have been developed by food researchers, which calculate the amount of lost days of shelf life as a function of temperature deviations (e.g. Tisjkens & Polderdijk 1996). Therefore, the intelligent container (IC) (Jedermann & Lang 2007) was developed in order to implement these developed models by capturing temperature deviations as soon and as accurate as possible. Hereby, the IC provides a processing platform for software agents. These agents evaluate shelf life losses and recommend actions. Standard refrigerated containers only measure the temperature in two points, but the temperature of the supply or return air does not represent the core temperature of the loaded pallets. However, a single container cannot carry out the necessary actions. Compensation for reduced quality as a part of the cargo is only possible within the logistic network. The planning process has to involve external factors, as the state of other ICs and a prediction of demand. Therefore, the IC applies a network of wireless sensors to capture a spatial temperature profile. Thus, the temperature of each pallet is either directly measured or mathematically evaluated (Jedermann & Lang 2009).

By way of illustration: Bananas are shipped from overseas to Europe. The total loss during transportation is in the order of few percent, but because bananas make up the highest share of refrigerated sea transports (Wild 2005), it can be assumed that these losses have a large ecological impact. Bananas are transported in a green unripe state by ship with typical transport duration of two weeks. During the subsequent artificial ripening the Bananas gain their yellow colour. The fruits are exposed to a high ethylene concentration in special ripening chambers. Each ripening room can typically hold the capacity of a 40 feet container. This ripening takes between 4 and 8 days. Afterwards, the bananas are transported to distribution centres and retail stores and sold within maximum of 10 days.

Small deviations of the quality state at arrival in Europe can be compensated by modifying the artificial ripening. Furthermore, controlled ripening is only possible if the chamber is loaded with bananas of equal initial quality. A mixed load of "light" and "dark" green bananas will create a poor result. Typically the temperature has a deviation of 1 °C or 2 °C over the length of the container during sea transport, which is caused by an uneven distribution of the cooling air. In order to compensate the resulting quality deviations the content of different containers can be mixed. The big banana import companies have the necessary infrastructure at their disposal, as high bay warehouses with access to single pallets. However, the required information base is currently incomplete. The quality is only evaluated by random samples by manual temperature measurement at arrival. The link of temperature and quality information per pallet to the infrastructure could provide a means for further reduction of product losses due to inaccurate ripening. Furthermore, an anticipatory planning of warehouse and ripening processes is enabled by real-time access to temperature and quality data during the transport. Consequently, the internal sensor focuses on the internal physical status of the container by measuring the temperature, atmospheric humidity or pressure. These physical variables enable a prediction of the lasting-times of the carried fruits and a ranking of the Container that mirrors the priority of being transported (e.g. "first expires, first out"; cf. Jedermann & Lang 2009).

Consequently, the IC comprises the technical features for the measurement of its internal status. However, the communication with other ICs is still a vision and a goal-oriented implementation of an external sensor network has not been implemented yet. The introduction of such an external perspective could make it possible to realize the complexity science-oriented vision of Complex Adaptive Logistics Systems (CALS) as introduced by Wycisk, Mckelvey & Hülsmann (2008). CALS consist of autonomous adaptive and heterogeneous agents (e.g. the IC) with the ability to learn that lead to co-evolutionary, emerging, evolving and self-organizing systems (Wycisk, McKelvey & Hülsmann 2008).

Therefore, the vision of the IC is to communicate via modern technologies, such as wireless networks with other ICs and with warehouses receiving information about the demand of required goods. By sending and receiving information about its own and the status of the other ICs, the ICs are able to make a priority of their transported goods (First expires, first served). Furthermore, the communication with transportation companies provides the IC with all available transportation routes including e.g. the price or duration of the transportation and destinations that have to be delivered. By computing the information from the internal and external sensors the ICs become so-called 'Smart Parts' that are defined by McKelvey, Wycisk & Hülsmann (2009) as *"[…] logistics entities, which possess the capabilities of interaction and autonomous decision-making through the usage of modern communication and information technologies, such as RFID, GPS, sensor networks and electronic markets (Ems)."* Consequently, the communication within such a logistics network would take external factors such as the state of other ICs and a prediction of demand into account and would try to find a best way or most efficient solution through autonomous cooperation and a decentralized decision making process. It can be assumed that suchlike technologies (e.g. self-controlling sensor networks) produce and process more goal-oriented information directly at the place of action very shortly (Hülsmann & Windt 2007) and that the logistic system then becomes a Complex Adaptive Logistic System (CALS) (McKelvey, Wycisk & Hülsmann 2009).

Wycisk, McKelvey & Hülsmann (2008) identified the following typical characteristics and outcomes of a CALS on the basis of Kauffman (1993), Holland (2005) and Mainzer (1994) listed in Table 1 and fitted to the introduced vision of implementing the IC in a fruit logistics network.

CALS-characteristics		CALS-outcomes	
Heterogeneity	The ICs as Smart Parts can be distinguished by their	Emergence	The behaviour of the whole network of the ICs is

	different priority due to their different internal status.		greater than the sum of its Smart Parts.
Ability to learn	The ICs as Smart Parts can modify their rules of action in order to improve their performance.	Adaptation	The behaviour of the whole network of the ICs adapts to changing conditions.
Interactivity	The ICs as Smart Parts can communicate with other Smart Parts that induces an adaptive reaction.	Non-linearity	The behaviour of the whole ICs-network is nonlinear due to unpredictable long-run effects.
Autonomy	The ICs as Smart Parts are responsible for their own direction and development.	Butterfly-effect	The behaviour of the whole ICs-network can depend on insignificant initial events.
Self-organization	The system arranges its own structure through its own capabilities and new patterns emerge that could not be predicted.	Scalability	The behaviour of the whole network of the ICs has a fractal structure.
Co-evolution	The system autonomously adapts to new environmental requirements to assure the systems´ survival that influences directly or indirectly the rest of the whole network.	Multi-levels	The behaviour of the whole network of the ICs results in structures in which an emergent whole at one level is a component of an emergent system at the next higher level.
Melting-zone	The system comprises a region between the edge of order and chaos.		

Table 1: Typical features of CALS fitted to the visionary scenario of implementing the IC into a fruit logistics network.

With recourse to the increasing relevance of environmental issues in logistics in general and in fruit logistics in special, the overarching question arises, if the implementation of such a technology can optimize or at least improve the environmental performance of a logistics network. Hence, on the basis of this complexity-theoretical framework, the question arises of how do these Smart Parts- and CALS-characteristics of a network consisting of ICs affect its emission of CO_2. Therefore, a model should be developed that reflects hypotheses about the existence of causal relationships between the visionary application of the IC and the ecological footprint in order establish a basis for getting first insights into the overarching question during further research. In order that an empirical analysis or simulation about these effects can be executed, causal relationship between these effects have to be assumed at first. For this reason, the following solution proposal will introduce a model approach that depicts the variables and outlines the existence of causal relationships in order to provide a basis on which these causal assumptions can be verified during further research.

A HYPOTHESIS-BASED STRUCTURAL EQUATION MODEL OF CO_2 EFFECTS OF CALS

The conceptual development of the hypotheses-based model comprises three steps: Firstly, causal relationships between the characteristics and the outcomes of CALS; secondly, causal relationships between the outcomes of CALS and their transportation effects and rate of rejection; finally, causal relationships between the transportation effects and/or rate of rejection and ecological effects.

It can be assumed that the expected CALS-characteristics of such autonomously cooperating ICs could take effects on the outcomes of CALS as Wycisk, McKelvey & Hülsmann (2008) imply. A possible explanation could refer e.g. to the heterogeneity of the agents within a system. The ICs can be distinguished by their different priority due to their different internal status (cf. Table 1). Furthermore, a different priority of an IC would lead to a different selection of possible warehouses and transportation routes. Therefore, due to all the differing priorities of the ICs (a CALS-characteristic) new structures (selection of transportation routes) would emerge and the structure of the system (CALS-outcome) would adapt to the – both internal and external – constraints. Therefore, it seems appropriate to hypothesize that characteristics of CALS listed in Table 1 would be connected with the outcomes of CALS in a causal manner. Furthermore, these emerging structures (e.g. the structures of the selected transportation routes) would be the same in the very rare cases. That is the reason why the accumulation of all the lengths of the routes would also not be the same. This leads to the possibility of assuming a causal relationship between the effects on the transportation efficiency and rejections rates and the ecological effects. Finally, CO_2 emissions are relatively straightforward to estimate, since they depend mainly on two factors (Wright 2008): The type and quantity of fuel burned, whereas the quantity basically depends on the length of the route and on the efficiency factor of the driving mechanism. At this juncture, the velocity, acceleration and transaction costs of sensor-networks could be neglected systematically (Wright 2008) but it can be hypothesized that the transportation effects (e.g. via a differing length of the routes) or rate of rejection (e.g. via a differing quantity of defective goods) have an impact on the emission of CO_2 because these effects would automatically have an impact on the type and quantity of the consumed fossil fuel. Due to the fact that the above-assumed causal effects make no claim to be complete the following Table 2 makes no claim to be complete either, by specifying the latent variables that cannot be directly observed and possible constitutive, indicating (measurable) variables as a first conceptual framework.

Latent variables	Exemplary constitutive, indicating variables
CALS-characteristics:	- Number of heterogeneous ICs
1. Heterogeneity	- Rate of external instructions
2. Autonomy	- Number of interactions in one time-step
…	- …
CALS-outcomes:	- Combinatorial transport routes
1. Emergence	- Duration of adaptation processes
2. Adaptation	- Growth factor
…	- …
Effects on transportation efficiency	- Length of the route
	- Cost of transport
	- Duration of transport
	- …
Effects on rejections rates	- Quantity of defective goods
	- Due date reliability
	- Transport capacity utilization
	- …
Ecological effects	- Emission of CO2

Table 2: Latent variables and their constitutive, indicating variables for the solution approach of the structural model

Based on Table 2, the following hypothesis for the causal relationships can be derived.

H_1: The characteristics of CALS are correlated through their indicating variables, e.g. a higher degree of heterogeneity, autonomy, etc. with the outcomes of CALS.

H_2: The outcomes of CALS are correlated through their indicating variables, e.g. an emergent structure with the effects on transportation efficiency and/or effects on rejection rates.

H_3: Effects on rejection rates are correlated through their indicating variables, e.g. the quantity of defected goods with the effects on transportation efficiency.

H_4: Effects on transportation efficiency are correlated through their indicating variables, e.g. the accumulated lengths of the routes with the ecological effects.

H_5: Effects on rejection rates are correlated through their indicating variables, e.g. quantity of defective goods with the ecological effects.

Up to now, a model that sets up and checks these assumed relationships between a network of autonomous cooperating ICs leading to the characteristics of CALS and the ecological footprint does not exist. Therefore, it is the idea to use the structural equation modelling as the methodology for the solution proposal, because it intends to test and estimate causal relationships by using a combination of statistical data and qualitative causal assumptions (Pearl 2000). Hereby, the structural model indicates potential causal relationships between latent variables and their indicators. Latent variables cannot be directly observed and measured. Furthermore, it is possible to observe several causal relationships between different variables simultaneously. In this case, latent variables are e.g. the above-mentioned characteristics and outcomes of CALS that are constitutively defined through their indicating variables, e.g. heterogeneity, self-organization, interactivity or emergence, non-linearity and scalability (cf. Table 1).

In this connection, two types of variables have to be distinguished: an independent and a dependent variable. Hereby, a dependent variable regresses on - or is being predicted by - the independent variable. The terminology of structural equation modelling states that a variable, which is regressing on another variable, is always an endogenous variable and it can also be used as an exogenous variable to be regressed on. While endogenous variables are graphically represented as the receivers of an arrowhead, exogenous variables are graphically represented as a sender of an arrowhead, indicating which variable it is explaining or predicting (Schumacker & Lomax 2004). According to Backhaus (2005) the structural equation modelling approach for analyzing CO_2-effects by implementing the IC in fruit logistics is shown schematically in Figure 1 that reflects the assumed causal relationships of the hypotheses H_1 – H_5.

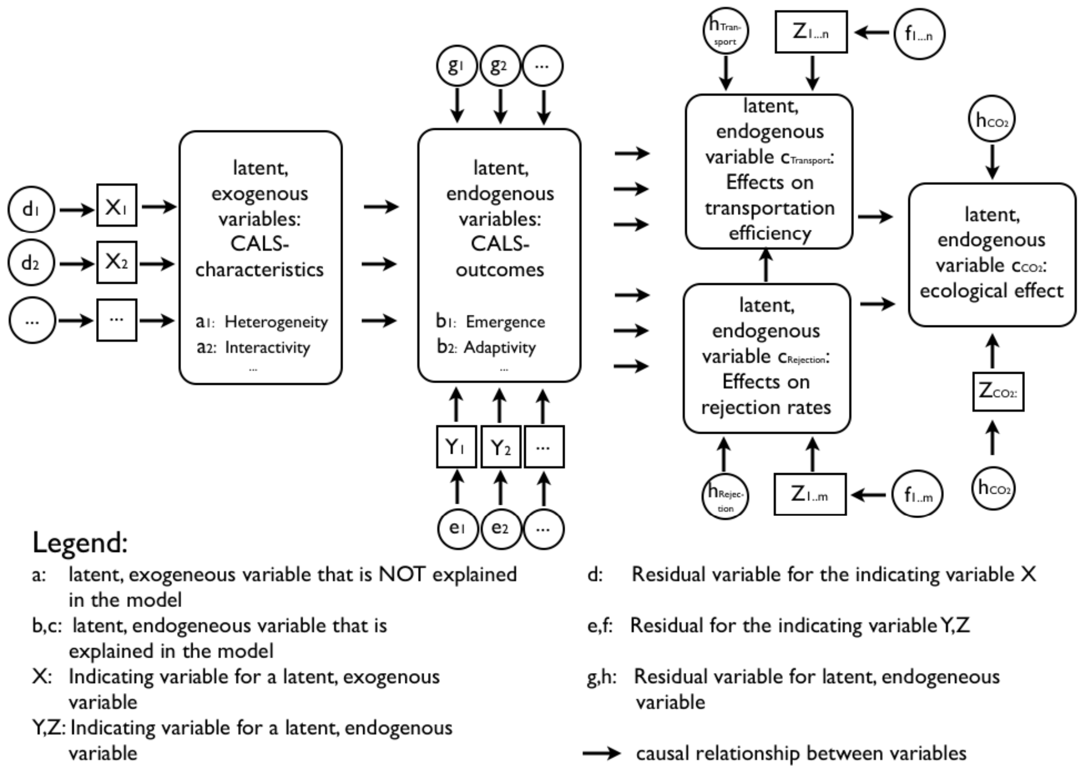

Fig. 1: Schematically representation of the Structural equation modelling approach for analyzing CO_2-effects by implementing the IC in fruit logistics

Therefore, the structural equation model contains the qualitative causal hypotheses between the smart characteristics of the network of the IC and CO_2-emissions at the end. The latent (independent), exogenous variables of the CALS-characteristics are not explained within the model and just indicated by their constituting variables (e.g. X_1 = number of heterogeneous ICs, cf. Table 1). Considering Figure 1 the constitutive indicating variables *Y* and *Z* for the latent (dependent), endogenous variables (CALS-outcomes, effects on transportation efficiency, effects on rejection rate and ecological effects) are the ones from Table 1. Finally, all the indicating variables *X, Y* and *Z* have to be operationalised and measured in further research for testing the assumed statistical correlations. At this point, Figure 1 also shows the residual variables *d*, *e*, *f*, *g* and *h* that represents other affecting influences due to noise, inaccuracies during the measurement and so on. In summary, the proposed hypotheses-based structural equation model comprises the assumed causal relationships and its structural model functions as the basis for measuring statistical data in further research. Conclusively, a structural equation model enables the verification of assumed interdependencies between several latent variables but the question arises about the contributions and limitations of this approach.

CONTRIBUTIONS AND LIMITATIONS OF THE PROPOSED HYPOTHESES-BASED STRUCTURAL EQUATION MODEL

On the one hand, some critical reflections on the weaknesses of the structural equation modelling approach in general shall be given. Herrmann, Huber & Kressmann (2006) mention the tendency to cursorily consider the relationship between the construct and its indicator. Furthermore, the use of reflective instead of formative variables could lead to a false conceptualisation or operationalisation. Additionally, the model needs a modification in order to improve the fit, though estimating the most likely causal dependencies between the variables. Hence, it is important that these modifications also make theoretical sense. Therefore, the term "causal model" must be understood carefully in the meaning of a model, which conveys "causal assumptions" (Hermann, Huber & Kressmann 2006).

On the other side, specific aspects of the given case have also to be considered. Because of the fact that the CALS-characteristics and outcomes depend on each other and that they can hardly be considered separately, current research on Complex Adaptive Systems lacks the quantified analysis of these phenomena (McKelvey, Wycisk & Hülsmann 2009). Furthermore, it has to be carefully deliberated, if all of the outcomes or only a selection (e.g. adaptivity and emergence) shall be directly implemented into the model because the most influential causal driver on the emission of CO_2 are not known at this point. Therefore, further research has to elaborate the characteristics and outcomes of these variables, e.g. the accuracy of the measured physical entities through internal sensors, the type, quality and quantity of information exchanged by the external sensor with the total or with parts of the sensor network, the mathematically evaluated priority of the transported goods and other programs for computing the other status and predicted demands and their degree of smartness or selfishness. Additionally, the characteristics and outcomes of CALS (e.g. self-organization) clearly lack a theoretical explanation in the sense of predicting the outcomes by knowing all underlying variables. Because of the high interconnectedness and its resulting complexity, it is nearly impossible to measure and calculate all information. Consequently, the model could only verify the assumed causal relations without giving a specific explanation about the underlying causal interconnectedness between the variables of Table 2. Finally, a fundamental collection of data and an empirical validation through the analysis of covariance in the measurement model is missing. Consequently, a verification and validation of the structural equation modeling for analyzing the CO2 effects by implementing the IC in fruit logistics is missing and the stability of the concept has not been proofed.

Nevertheless, the main contributions towards the proposed hypothesis-based structural equation model are manifold: Firstly, the structural model assumes the existence of potential causal relationships between latent variables and their indicators; secondly, the structural equation model would make it inherently possible to verify the existence and to identify directions of action of these causal assumptions between the visionary implementation of the IC and the emission of CO_2; thirdly, it could imply possible actions for realising positive ecological impacts; fourthly, these assumed causal relationships could enable a more detailed empirical analysis or simulation in further research; finally, the model could be extended or adjusted at any time by adding more causal relationships.

CONCLUSIONS

This paper intended to conceptually develop a model that is able to reflect variables and the existence of causal relations between the network of ICs as a CALS and the CO_2-emissions. The main contributions towards the described solution approach are the verifiable compilation of causal assumptions by considering the complexity of today's International Supply Networks in order to realise positive ecological impacts. Further research should focus on the remaining limitations to understand the underlying dependencies and improve the model regarding the desired goals by quantifying the characteristics of CALS. In contrast, the measurement of transportation and stocking effects in Table 1 are much easier to detect. However, since the exact relations of implementing the IC into a large fruit logistics network are currently unknown (strategic benefits e.g. in form of system flexibility and adaptivity), the information processing calculation within the IC has to be thoughtful constructed and implemented, since different target functions are possible, e.g. the efficiency or the robustness that all indirectly influence the ecological impacts.

REFERENCES

Backhaus, K. 1995. "Investition". *Investitionsgütermarketing*, 4th edn., München

Herrmann, A., Huber, F. & Kressmann, F. 2006. "Varianz- und Kovarianzbasierte Strukturgleichungsmodelle – in Leitfaden zu deren Spezifikation, Schätzung und Beurteilung". In: *Zeitschrift für Betriebswirtschaftliche Forschung*, No.58, pp. 34-66.

Holland, J.H. 2002. "Complex Adaptive Systems and Spontaneous Emergence". In Curzio, A.Q. and Fortis, M. (Eds), *Complexity and Industrial Clusters*, Physica, Heidelberg, pp. 25-34.

Hülsmann, M. & Windt, K. 2007, *Understanding Autonomous Cooperation and Control in Logitics*, Heidelberg.

Klaus, P. & Kille, C. 2008, *Die Top 100 der Logistik: Marktgrößen, Marktsegmente und Marktführer in der Logistikdienstleistungswirtschaft,* Deutscher Verkehrs Verlag, Hamburg.

Jedermann, R. & Lang, W. 2007. "Semi-passive RFID and beyond: steps towards automated quality tracing in the food chain". In: *International Journal of Radio Frequency Identification Technology and Applications (IJRFITA)*, Vol. 1(3), pp. 247-259.

Jedermann, R. & Lang, W. 2009. "The minimum number of sensors - Interpolation of spatial temperature profiles". In: *Rödig, U.; Sreenan, C.J.,(eds.): Wireless Sensor Networks, 6th European Conference, EWSN 2009, Lecture Notes in Computer Science (LNCS),* Berlin/Heidelberg, Springer, 2009, Vol. 5432, pp. 232-246. (doi: 10.1007/978-3-642-00224-3_15)

Kauffman, S.A. 1993. *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, NewYork, NY.

McKelvey, B., Wycisk, C. & Hülsmann, M. 2009. „Designing an Electronic Auction Market for Complex 'Smart Parts' Logistics: Options Based on LeBaron's Computational Stock Market", in: *International Journal of Production Economics*, 120, pp. 474-494.

Mainzer, K. 1994. *Thinking in Complexity: The Complex Dynamics of Matter, Mind, and Mankind*. Springer, New York, NY.

New, S. & Westbrook, R. 2004. *Understanding Supply Chains: Concepts, Critiques, and futures*. New York: Oxford University Press.

Pearl, J. 2000. *Causality: Models, Reasoning, and Inference*. Cambridge University Press.

Scheer, F.P. 2006. "Optimising supply chains using traceability systems". In: *Smith, I.; Furness, A.,(eds.): improving traceability in food processing and distribution*, Woodhead Publishing Ltd., Cambridge, England, pp. 52 - 64.

Schumacker, R.E. & Lomax R.G. 2004. *A Beginner´s Guide to Structural Equation Modelling.* Lawrence Erlbaum Assoc Inc. 2nd Edition.

Sklorz, A., Miayshita, N. & Lang, W. 2010. "Miniaturised Gas Chromatographic System for Ethlene Detection in Fruit Logistic". In: *Smart Systems Integration*, Como, Italy, VDE-Verlag, Berlin.

Tijskens, .M.M. & Polderdijk, J.J. 1996. "A generic model for keeping quality of vegetable produce during storage and distribution". In: *Agricultural Systems*, Vol. 51(4), pp. 431-452. (doi: 10.1016/0308-521X(95)00058-D)

Wild, Y. 2005. „Kühlcontainer und CA-Technik". In: *Wild, Y.; Scharnow, R.; Rühmann, M.,(eds.): Containerhandbuch, Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV)*, Berlin, Vol. 3, pp. 19-101.

Wright, T. & EMOND, J.-P. 2008. *Cool Chain Association CO2 Project Report – A confidential report commissiond by the Cool Chain Association (CCA) and designed to support the CCA Board in its work within the Perishables & Temperature Sensitive Products sector.*

Wycisk, C., McKelvey, B. & Hülsmann, M., 2008. "´Smart Parts´logistics systems as complex adaptive systems". In: *International Journal of Physical Distribution and Logistics Management*, Vol. 38(2), pp. 108-125.

ENVIRONMENTAL KNOWLEDGE MANAGEMENT FOR SUSTAINABLE 'GREEN' MANUFACTURING OPERATIONS: A CASE STUDY OF A STEEL MANUFACTURING FIRM IN MALAYSIA

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ABSTRACT
Growing concerns over environmental sustainability has made it necessary for many organisations to go 'green' in its operations to ensure that it minimises it environmental footprint for competitive advantage as well as corporate social responsibility reasons. This paper analyses the environmental knowledge management practices of a steel manufacturing firm as it 'greens' its manufacturing operations to attain ISO14001 certification. A case study approach was used in this study which reveals that effective implementation of the SECI model to manage environmental knowledge has enabled it to achieve its EMS certification goal and that the socialisation and internalisation aspects of environmental knowledge management are the two key knowledge creation modes which it applied.

INTRODUCTION
With increasing awareness of sustainable practices and environmental protection worldwide, the 'green' wave of conserving the Earth's finite resources and protecting the environment have received overwhelming attention (Chien & Shih, 2007). The pressure and constant hyper competition brought about by globalization and rapid industrialisation have prompted organizations to improve their performance from an environmental point of view in addition to business profits and market share (Sheu, et al., 2005). The pressure on organizations to improve their environmental performance stems from the move towards globalisation and a more environmentally-conscious population (Sarkis & Tamarkin, 2005). The problem is further exacerbated with local environmental problems escalating into global pollution issues through globalization and the Earth's natural processes (Huang & Shih, 2009).

Global environmental pollution has been recognised as the main problem which has the greatest potential to lead to the degradation of our environment, leading to the extinction of human mankind on Earth (Ho, Shalishali, Tseng, & Ang, 2009). Since the middle of the 20th century, the increase of the greenhouse gases concentrations resulting from human activities which include fossil fuel burning, deforestation and industrialization (Intergovernmental Panel on Climate Change, 2007). Greenhouse gases are the main cause of global warming which causes the increase in the average temperature of Earth's near-surface air and oceans and it is still projected to increase over the years (Intergovernmental Panel on Climate Change, 2007).

The extraordinary growth of the global economy in the last 50 years have resulted in a heavy burden on the environment, one that is increasing as many formerly underdeveloped parts of the world choose to follow the route of the more prosperous nations (WBCSD, 1997a). Natural resources such as mineral ores, fossil fuel, agricultural productivity and environment self-purification have their own limits and are going to reach its capacity (WBCSD, 2006). Irrational resource consumption together with irresponsible environmental pollution resulting from the product life cycle - raw material acquisition, manufacturing, consumption and disposal are the main reasons that have pushed the world's global environmental carrying capacity to its limit (Matos & Hall, 2007).

Sustainable development involves business, government, communities and households that contribute to the improvement of environmental quality through the effective production and consumption of natural resources with the goal to minimize waste and optimize the products and services (WBCSD, 1997b). The World Business Council for Sustainable Development (WBCSD) have recognised the necessity of businesses to take a lead role in promoting sustainable development in its production and resource consumption to meet societal needs within ecological limits (WBCSD, 1997b). The attainment of these goals would undeniably enhance business competitiveness and realise profitable operations through responsible environmental management (WBCSD, 1997b).

Malaysia is a fast moving developing country moving towards industrialized economy which has seen it move away from raw material and agricultural production to manufacturing, considered to be a remarkable achievement especially in the last two decades (Fadzilah Ahmad & Krishna, 2007; Tarig Khidir Eltayeb & Zailani, 2009). Malaysia is still being considered as developing country which focuses on economic development and therefore seeks to strike a balance between national development and environmental protection. Nowadays, the Malaysian government has taken the initiative to move towards sustainable manufacturing processes to ensure that its products and services are marketable to the more developed regions of the world such as the European Union which are produced in a sustainable manner. Therefore, Malaysian business organizations have begun to implement green supply chain management and environmental knowledge management practices for competitive advantage.

Even though the aim of organizations implementing GSCM is to enhance environmental and financial performance, the scope of GSCM practices is wide and includes internal environmental management, external GSCM, investment recovery and eco-design or design for environmental practices (Zhu & Sarkis, 2004). In line with the increased need to manage these new practices, processes and mindset, knowledge management has therefore secured a relevant role in the interpretation of the competitive potential of an organization among managerial disciplines with the capability to generate, process and exchange environmental knowledge (Volpato & Stocchetti, 2007). This has also resulted in the emergence of a new form of knowledge management known as environmental knowledge management to connect data, analysis and people which presents an opportunity to formalize industrial ecology in a business setting (Wernick, 2003) to enable employees to gain environmental awareness and make environmentally-responsible business decisions (Huang & Shih, 2009).

As such, the main objective of this paper is to identify the extent and scope of environmental knowledge management practised in a steel manufacturing firm in Malaysia and to evaluate its performance from the point of view of the sustainable and green manufacturing operations. The following section will provide an overview of the extant literature on green supply chain management and environmental knowledge management before briefly explaining the research method employed for this study. Next, the findings of the study shall be presented in terms of the environmental problems faced, environmental policy and actions taken by the firm and the environmental knowledge management practices employed by the employees before arriving at the conclusion for this study.

LITERATURE REVIEW

Green supply chain management (GSCM)

GSCM is a concept that emerges from the environmental management discipline to achieve sustainable development in the context of supply chains (Sarkis, 2006; Walton, Handfield, & Melnyk, 1998). In addition to that, the key reason for investing in GSCM implementations are to realise resource savings, waste elimination, productivity improvement and ultimately cost saving and environmental performance enhancement for sustainable development (Srivastava, 2007). Hence, this has resulted in GSCM changing from being a business burden to a potential source of competitive advantage (van Hock, 1999).

GSCM practices are now recognized as the primary strategy capable of complying with the legislative requirement and market trend for sustainable development to maintain competitive advantage (Hsu & Hu, 2008). According to Dan and Liu (2000), GSCM is a modern management practice that considers environmental impact and the efficiency of resource distribution, involving suppliers, producers, sellers and users which spans the entire product life cycle with the purpose to reduce environmental impact. GSCM is not just an environmentally-friendly managerial practice but makes good business sense for higher profit and market share (Srivastava, 2007). It is therefore a business value driver and not a cost centre (Wilkerson, 2005).

There are three GSCM approaches which are namely reactive, proactive and value-creating (Kopicki, Legg, Berg, Dasappa, & Maggioni, 1993; van Hock, 1999). First, the reactive approach means that organizations only maintain minimal resources for environmental management to reduce the environmental impact of production such as product labelling. The proactive approach is where organizations take the initiative to comply with new environmental regulations, committing to product recycling and green product design. In the value-creating approach, organizations actively integrate environmental management system into their business strategy such as green purchasing and reverse logistics.

According to van Hock and Erasmus (2000), GSCM have become an important organizational philosophy to enhance competitiveness to achieve higher profits and market share by not only reducing environmental risks and impacts but improving the organization's ecological performance. As a result, supply chain management with environmental integration is gaining a more important position among manufacturers looking to achieve and maintain its competitive advantage in today's business environment (Zhu, Sarkis, & Lai, 2008).

Environmental knowledge management (EKM)

Environmental management is a managerial skill that identifies the way an organization manages the natural environment and minimizes the entire operation's negative impacts on the environment (Klassen & McLaughlin, 1996; Welford, 2000). The principles of environmental management define the policies, procedures, practices, objectives, targets and audit scheme therefore providing a catalyst for continuous improvement to control the operations or processes that create waste materials or emissions (Matthews, 2003). All these principles were developed according to and comply with environmental management systems (EMS) such as the British standard for EMS BS 7750, European Union's Eco-Management & Audit Scheme (EMAS) and ISO 14000 (Bansal & Roth, 2000). All these standards therefore propose a framework to fully integrate environmental and business management practices that would allow organizations to take on a more proactive approach towards managing environmental issues (Lally, 1998).

Environmental management principles and standards have been recognised as useful tools for an organization to improve its environmental performance, however these principles and standards are only focussed on creating and documenting environmental policies and procedures (Curkovic, Sroufe, & Melnyk, 2005). Therefore, such policies and procedures are mainly to improve environmental performance within the organization's operational boundaries rather than the involvement of its entire supply chain (Bansal & Roth, 2000; Handfield, Sroufe, & Walton, 2005). If compared with the conventional supply chain, organisations with green supply chain take the full responsibility of the product life cycle right from the acquisition of raw materials until end user and product disposal (Hart, 1997). Green supply chain applies environmental management principles to the whole set of product life cycle activities which involve the design, procurement, manufacturing and assembly, packaging, distribution and disposal of materials (Handfield, Walton, Seegers, & Melnyk, 2007; Zsidisin & Siferd, 2001).

Accordingly, Huang and Shih (2009) believe that the combination of environment management together with knowledge management is a strategic tool to achieve sustainable development. Wernick (2003) recognises this dynamism and therefore defines environmental knowledge management as a system to interconnect data, analysis, and people by provide a platform to formalize high industrial ecology standard in a business setting. However, this brings rise to a new issue that is faced by both managers and researchers which is how to combine both environmental management and knowledge management effectively and apply it in the real world (Huang & Shih, 2009).

Organisations hence apply the concept of environmental knowledge management to monitor the environmental impact emanating from its operations through the creation, accumulation, sharing, utilization and internalization of environmental knowledge which require the combine management of tacit knowledge and explicit knowledge (Huang & Shih, 2009). Environmental knowledge management is a tool than can be used for the integration of environmental problems into business organization's routine operations with the aim of minimising environmental impact and increasing corporate social responsibility (Huang & Shih, 2009).

Hence, organisations are able to create new knowledge through the knowledge conversion process which involves the interaction between tacit knowledge and explicit knowledge (Nonaka, Toyama, & Konno, 2000). Both tacit and explicit knowledge will grow in terms of quality and quantity via the knowledge conversion process which involves socialisation, externalisation, combination and internalisation (Nonaka, Byosiere, Borucki, & Konno, 1994; Nonaka & Takeuchi, 1995). Nonaka et al. (1994) identified the four modes of knowledge conversion as:

i. **Socialization** (from tacit knowledge to tacit knowledge) is a process to convert new tacit knowledge via experience sharing. However, tacit knowledge is difficult to be quantified as it is often time-specific and space specific by spending time together or living in the same environment.

ii. **Externalization** (from tacit knowledge to explicit knowledge) is a process to articulating tacit knowledge into explicit knowledge. Naturally, it is not easy to convert tacit knowledge into explicit knowledge but through the conceptualization method, some proportion of tacit knowledge could be captured in explicit knowledge form (Choo, 1998; Takeuchi & Nonaka, 2004). The sequential use of metaphors, analogies and models are able to facilitate the conversion of tacit knowledge into explicit knowledge.

iii. **Combination** (from explicit knowledge to explicit knowledge) is a process to convert explicit knowledge into meaningful and systematic sets of explicit knowledge. The information is collected from inside and outside of the organization to combined, edited and processed to generate new knowledge which will be disseminated among members of the organization. Large scale and comprehensive use of information database systems and computerized communication networks are able to facilitate this mode of knowledge conversion.

iv. **Internalization** (from explicit knowledge to tacit knowledge) is a process that embodies explicit knowledge into tacit knowledge. During the internalization process, individuals convert the shared explicit knowledge in organizations into their tacit knowledge. Internalization is a process that emphasizes learning by practice through training programmes, simulations or experiments and reading documents or manuals to enrich their tacit knowledge base.

RESEARCH METHOD

To identify the extent and scope of environmental knowledge management practiced in a steel manufacturing firm in Malaysia and to evaluate its performance from the point of view of the sustainable and green manufacturing operations, this study employs the use of observations, in-depth semi-structured interviews and document review at a steel manufacturing firm in Malaysia. This study examines how environmental knowledge sharing behaviours exists in the firm and its effect on the efficiency of its environmental management practices based on the socialization, externalization, combination and internalization (SECI) model by Nonaka and Takeuchi (1995).

To ensure that an in-depth and representative account of the practices can be obtained, the principal researcher was stationed within a department in the firm over an extended duration of 3 months. This allowed the researcher to obtain insights and a first-hand view of the environmental knowledge management practices in the firm. In order to ensure the confidentiality of the respondents and the firm, identifying data has been masked in order to ensure that the 'avoidance of harm' principle of research ethics is adhered to. In addition to that, the respondents were made known of the intent of the study and their participation in the interviews was voluntary.

The steel manufacturing firm used as the case study started its operation in the 1990s is a public-listed company with revenue of over RM 1 billion. Over 600 employees who include top management, middle management, administrative, engineers, technicians, operators, and supporting staff are employed in this organisation. It is ISO9002 and ISO9001 certified prior to this study and was actively in the process of obtaining its ISO14001:2004 certification. In the process of obtaining this environmental certification, it faced an arduous task of disseminating environmental knowledge among its employees and ensuring that this knowledge is shared and effectively deployed throughout its supply chain.

FINDINGS

Environmental problems and initiatives

The environmental problems faced in steel manufacturing industries are numerous as the production processes and maintenance activities involve of a lot of hazardous substances like raw materials, chemical substances, tools, equipments and radioactive materials. Therefore, the solution to this company's environmental problems is complex and this study is therefore delimited in its scope by investigating the water pollution, solid waste and air quality issues. A large amount of the water will be used and disposed in the steel manufacturing industries daily operations for dust removal, electrolytic cleaning water and cooling purposes. The disposed waste water was high levels of oil and many hazardous chemical substances which will seriously destroy environment if disposed without any proper treatment. On the other hand, the main source of the solid waste is the used oiled gloves, textiles, disposed equipment and grease which are common waste products of maintenance activities. The CO2, SOX, and NOX emissions released during the steel manufacturing process causes air pollution. With the used of the environmental knowledge management in its supply chain practices, this firm was able to innovate the new technologies and new methods to reduce the hazardous industrial waste.

In line with its move towards ISO14001:2004 certification, the firm established the Environmental Protection Department (EPD) and Occupational Safety and Health Department (OSHD) responsible for the environmental and occupational safety and health issues respectively. These departments receive strong support from the top management that have a biannual strategic planning meeting to review the respective departments' accomplishments and to decide on strategic actions required by the firm. Among the policies formulated by the firm are (1) continually improving the operational techniques and environmental management system; (2) managing operational equipment and industrial waste effectively; (3) ensuring compliance with all applicable laws and regulations; (4) promoting the involvement of employees in its EMS certification initiative. To accomplish these green environmental policies and the 'greening' of its supply chain, this company launched several programmes to address to the environmental issues affecting the firm which include (1) quarterly environment monitoring of ambient air, chimney stack, effluent, water quality, and noise; (2) yearly environmental audit by consultants; (3) environment management planning reporting; (4) energy savings measurement; and (5) recycling activities.

Socialisation

In the firm, department managers accumulate the tacit knowledge by gathering the knowledge and sharing of experiences with their subordinates, suppliers, and customer to the extent of engaging in dialogue with its competitors. The socialization activities include a daily morning knowledge sharing session, meal time, and social activities. For each department, the daily morning knowledge sharing session will be held just before the commencement of operation. This session will be attended by all the engineers and technicians or operators including the department's manager. The purpose of this session is aim to share the knowledge and experiences by the all level of staff in that particular department. Open communication also plays a key role in the socialization process as evidenced in the firm with its daily morning sharing session which is conducted by engineers with technicians, requiring all participants to share their individual experiences, insights and perspectives.

The manager of the mechanical maintenance department claims that "I am able to receive feedback every day which is a great help for me to keep my plans current…..this is only possible with two-way communication". This kind of sessions will act as an informal discussion to build rapport that would accelerate environmental knowledge sharing among members within the same department. New staff members are able to learn directly from seniors by gaining environmental knowledge and experiences which cannot be obtained easily in documented form.

The free meals provided by the firm to its employees not only cater to the employees' welfare but acts as a platform to enhance the cross-functional environmental knowledge sharing process. An operator explains that "I really enjoy the meals … and I always talk to my colleagues about my experiences with EMS initiatives when we are together for meals". This enhances the degree of cooperation and innovativeness between the departments dramatically. In addition to that, the firm's suppliers and contractors are also invited to join in the meals to encourage socialisation and the development of better social bonds.

Externalization

This firm is proactive in innovating new processes and products and embarked on a program called 'innovation reward' that pays out cash prizes to promote an innovative culture among the employees. All employees are strongly encouraged to suggest innovative ideas that could in cost reduction, reducing environmental impacts, and occupational and health issues. Successful ideas will receive a cash reward up to 10% of the total cost savings realised. In order to encourage inter-organisational knowledge sharing and the externalisation of partner knowledge, this programme is open to its partners.

Apart from that, the firm also uses questionnaires to obtain feedback from employees regarding its environmental performance. This allows the organisation to analyse all the data collected and process it into useful information for continuous improvement purposes. "I like the questionnaire feedback system….I can express my opinions without having to confront my supervisor face to face" claims a QA engineer. The anonymity afforded by this approach proves to be effective in eliciting tacit knowledge and opinions of employees. In addition to that, the EPD conducts meetings and brainstorming sessions to accumulate meaningful environmental information. These sessions allow the engineers to realise the problems or issues in a timely manner and figure out the potential solutions.

Combination

The combination mode of knowledge conversion is commonly practised in the firm where managers and engineers actively gather required knowledge internally or externally using the published literature, computer simulation and forecasting. With a relatively advanced IT infrastructure, the firm is able to use it as a platform to share environmental management documents and explicit knowledge with its employees. Whenever engineers are faced with an environmental knowledge requirement or a problem, they can look up for similar cases in the past to solve their problems. The repository of past cases lets employees solve environmental problems more effectively as noted by an engineer "the MIS is a powerful tool for environmental information storage and manipulation … without it, knowledge sharing regarding ISO14001 issues would be difficult".

Environmental auditing is an important component in the GSCM to form a cycle to ensure that the firm implements the correct policies and that these policies are effectively executed. It is intended to quantify the environmental performance and environmental position of the firm. The environmental audit reports conducted in the firm contains a statement of the firm's environmental performance and environmental position, and may defines what needs to be done to sustain or improve on indicators of such performance and position. It allows the firm to assess its compliance with the relevant statutory and internal requirements, facilitates management control of environmental practices, promotes good environmental management, raises staff awareness and enforces commitment to departmental environmental policies, explores improvement opportunities and establishes the performance baseline in the firm's ISO14001 pursuit. The top management of the firm acknowledges that environmental auditing plays an important role in the firm's EMS initiative and allows both the combination of various documents and perspectives in an objective manner, which is easily acted upon by management. In addition to that, the external environmental audits conducted by external consultants are useful in the initial stages of EMS implementation as mentioned by an environmental engineer as it "… can always point out some issues that we never figured out before".

Internalization
The firm practices internalisation through its knowledge documentation processes and hands-on learning approaches. The firm has been able to accumulate a wealth of knowledge and experience which are then published as handbooks and guidelines to improve the employees' occupational knowledge. These handbooks and guidelines include the company's policies and standard operating procedure (SOP) for solving the frequently- faced problems. Engineers are also encouraged to document their knowledge in these documents to be shared and adopted by their colleagues.

The firm realised that most of the technicians and operators are generally not highly educated and some of them are not literate. Despite their low educational qualifications, they are knowledgeable in their task and roles. Implementing a new EMS is a steep learning for everyone and in recognition of this segment's contribution to the firm, the top management had to find a way to ensure that they are able to learn the new processes and standards effectively. At the end, a hands-on training approach was adopted which involves the use of mock exercises and on-the-job training (OJT).With the application of OJT, it makes the employees able to internalize the explicit environmental knowledge into tacit knowledge. In addition, employees are encouraged to participate in the conferences and training courses regularly. This not only creates environmental awareness among engineers but allows them to update their environmental knowledge and skills to be applied at work.

CONCLUSIONS
This study has outlined the role of environmental knowledge management in improving the efficiency of green supply chains management and the attainment of EMS certification as knowledge sharing and experiences exchanges become key issues in environmental knowledge management. It can be observed that the implementation of the SECI model by Nonaka and Takeuchi (1995) has allowed the firm to effectively mobilise its environmental knowledge to successfully achieve its environmental goals and green its supply chain. More importantly, the firm was able to come up with novel ways

via knowledge socialisation and internalisation to ensure its employees adhere to the environmental and safety policies.

REFERENCES

Bansal, P., & Roth, K. (2000). Why companies go green: a model of ecological responsiveness. *Academy of Management Journal, 43*(4), 717-736.

Chien, M. K., & Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organizational performances. *International Journal of Environmental Science and Technology, 4*(3), 383-394.

Choo, W. C. (1998). *The Knowledge Organization – How organizations use information to construct meaning, create knowledge and make decision*. New York: Oxford University Press.

Curkovic, S., Sroufe, R., & Melnyk, S. A. (2005). Identifying the factors which affect the decision to attain ISO 14000. *Energy, 30*(8), 1387-1407.

Dan, B., & Liu, F. (2000). Study on green supply chain and its architecture. *China mechanical engineering, 11*(11), 1232-1234.

Fadzilah Ahmad, & Krishna, V. V. (2007). *Science and Technology Policy and the Dynamics Underlying the Malaysian Innovation System*.

Handfield, R. B., Sroufe, R., & Walton, S. V. (2005). Integrating environmental management and supply chain strategies. *Business Strategy and the Environmental, 14*(1), 1-19.

Handfield, R. B., Walton, S. V., Seegers, L. K., & Melnyk, S. A. (2007). 'Green' value chain practices in the furniture inductry. *Journal of Operations Management, 15*(4), 293-315.

Hart, S. L. (1997). Beyond greening: strategies for a sustainable world. *Harvard Business Review, 75*(1), 66-76.

Ho, J. C., Shalishali, M. K., Tseng, B. T. L., & Ang, D. S. (2009). Opportunities In Green Supply Chain Management. *The Coastal Business Journal Spring 2009, 8*(1), 18-31.

Hsu, C. W., & Hu, A. H. (2008). Green supply chain management in the electronic industry. *International Journal of Environmental Science and Technology, 5*(2), 205-216.

Huang, P. S., & Shih, L. H. (2009). Effective environmental management through environmental knowledge management. . *International Journal of Environmental Science and Technology, 6*(1), 35-50.

Intergovernmental Panel on Climate Change. (2007). Climate Change 2007: Synthesis Report *Summary for Policy Makers*. Geneva.

Klassen, R. D., & McLaughlin, C. P. (1996). The impact of environmental management on firm performance. *Management Science, 42*(8), 1199-1214.

Kopicki, R. J., Legg, L., Berg, L. M. J., Dasappa, V., & Maggioni, C. (1993). *Reuse and Recycling: Reverse Logistics Opportunities*: Oak Brook, IL: Council of Logistics Management.

Lally, A. P. (1998). ISO 14000 and environmental cost accounting: the gateway to the global market. *Law and Policy in International Business, 29*(4), 501-538.

Matos, S., & Hall, J. (2007). Integrating sustainable development in the supply chain: the case of life cycle assessment in oil and gas and agricultural birtechnology. *Journal of Operations Management*

Matthews, D. H. (2003). Environmental management systems for internal corporate environmental benchmarking. *Benchmarking: An International Journal, 10*(2), 95-106.

Nonaka, I., Byosiere, P., Borucki, C. C., & Konno, N. (1994). Organizational knowledge creation theory: A first comprehensive test. *International Business Review, 3*(4), 337-351.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge – Creating Company - How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation. *Long Range Planning, 33*(2000), 5-34.

Sarkis, J. (2006). *Greening the Supply Chain* London: Springer.

Sarkis, J., & Tamarkin, M. (2005). Real options analysis for"green trading": the case of greenhouse gases. *Engineering Economist 50*, 273-294.

Sheu, J. B., Chou, Y. H., & Hu, C. C. (2005). An integrated logistics operational model for green-supply chain management. *Transportation Research, 41*(4), 287-313.

Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53-80.

Takeuchi, H., & Nonaka, I. (2004). *Hitotsubashi on Knowledge Management*. Singapore: John Wiley.

Tarig Khidir Eltayeb, & Zailani, S. (2009). Going Green Through Green Supply Chain Initiatives Towards Environmental Sustainability. *Operations and Supply Chain Managment, 2*(2), 93-110.

van Hock, R. I. (1999). From reversed logistics to green supply chains. *Supply Chain Management 4*(3), 129-135.
van Hock, R. I., & Erasmus. (2000). From reversed logistics to green supply chains. *Logistics Solutions, 2*, 28-33.
Volpato, G., & Stocchetti, A. (2007). Knowledge management in the automotive supply chain: exploring suppliers point of view. *International Journal of Automotive Technology and Management, 7*(2/3), 184-199.
Walton, S. V., Handfield, R. B., & Melnyk, S. A. (1998). The green supply chain: integrating suppliers into environmental management process. *International Journal of Purchasing and Materials Management, 34*(2), 2-11.
WBCSD. (1997a). Exploring Sustainable Development *WBCSD Global Scenarios 2000 - 2050*. London.
WBCSD. (1997b). Sustainable Production & Consumption from a Business Perspective: WBCSD.
WBCSD. (2006). Eco-efficiency, from www.wbcsd.org/DocRoot/
Welford, R. (2000). *Corporate Environmental Management: Towards Sustainable Development*. London: Earthscan Publications Ltd.
Wernick, I. K. (2003). Environmental knowledge management. *Journal of Industrial Ecology 6*(2), 7-9.
Wilkerson, T. (2005). *Can One Green Deliver Another?* : Havard Business School Publishing Corporation.
Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operation Management, 22*, 265-289.
Zhu, Q., Sarkis, J., & Lai, K.-h. (2008). Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics, 111*, 261-273.
Zsidisin, G. A., & Siferd, S. P. (2001). Environmental purchasing: a framework for theory development. *European Journal of Purchasing & Supply Management, 7*(1), 61-73.

STUDY OF ENVIRONMENTAL ACTIVITIES BY NEWSPAPER INFORMATION ARTICLES

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ABSTRACT:
Recently, environmental problems have been pointed out as serious problems for living things. Environmental protection actions have mainly been executed by governmental regulations. Many companies, however, execute their own environmental protection actions or CSR actions spontaneously. We consider that such spontaneous environmental protection actions have been affected by economic and public opinion factors. We therefore studied environmental protection actions by investigating the rate of occurrence of environmental terms in Japanese such as global warming, ozone layer destruction, and waste recycling in articles in Japanese newspapers, and analyzed the relationship between environmental protection actions and the time period of an environmental problem by performing correlation analysis.

We considered the following hypotheses regarding the features of an environmental problem.

1. The period of awareness of some specific environmental problems was shorter than that of other environmental problems. We believe that this phenomenon occurs without regard to actual environmental problems.

2. Since the establishment of environmental countermeasures requires time, there is a delay in the occurrence of terms as countermeasures in newspaper articles.

For example, the rate growth of the occurrence of solar cells as a countermeasure for global warming in Japanese newspaper required 10 years after rate of occurrence of global warming grew in Japanese newspapers. We felt that there were some questions regarding environmental protection actions.

We then performed in in-depth analysis of the rate of occurrence, in order to identify the main reasons for delays in countermeasures, and we will further consider by newspaper analysis economic conditions and public opinion factors as they affect environmental protection action. We believe that this approach of analyzing newspaper articles might indicate some masked factors.

1. Purpose:

We try to determine the main factor for decision-making to implement environmental protection action.
One factor for decision-making in the implementation of environmental protection actions is obviously economic condition factor[1)].

The final goal of this series study is to show how to develop accelerated methods for emergence environmental protection actions. We wish to execute decision-making for environmental protection action by many corporations or society.

2. Method:

We first selected keywords using NIKKEI TELECOM-21[2)] and EL-NET[3)]. NIKKEI TELECOM-21 can search more than 100 newspapers and magazines from 1975 (approximately 4 million articles). EL-NET can search more than 200 newspapers and magazines from

1988 (approximately 17 million articles). Newspaper article studies have been reported in the literature[4].

We found global warming, ozone layer destruction, waste recycling, and the Japanese-specific environmental problem of dioxin had high rates of occurrences, appearing in more than 80 thousands.

The environmental problem exhibiting a high rate of occurrence was noise pollution. Because noise pollution, however, is very small-area problem and the cause and results are very clear, we ignored noise damage (or noise nuisance) in this study.

Before selecting keywords, we considered the environment classification or grouping in "The Environmental Goods & Services Industry (1999)"[5]. Fig. 1 shows the relation between environmental problems and the three aspects of scale, viewpoints, and subjects. New classification or grouping should be developed for an improved understanding of environmental problems.

While our understandings are based on this complicated environmental classification or grouping, this classification or grouping problem will be a target for future study.

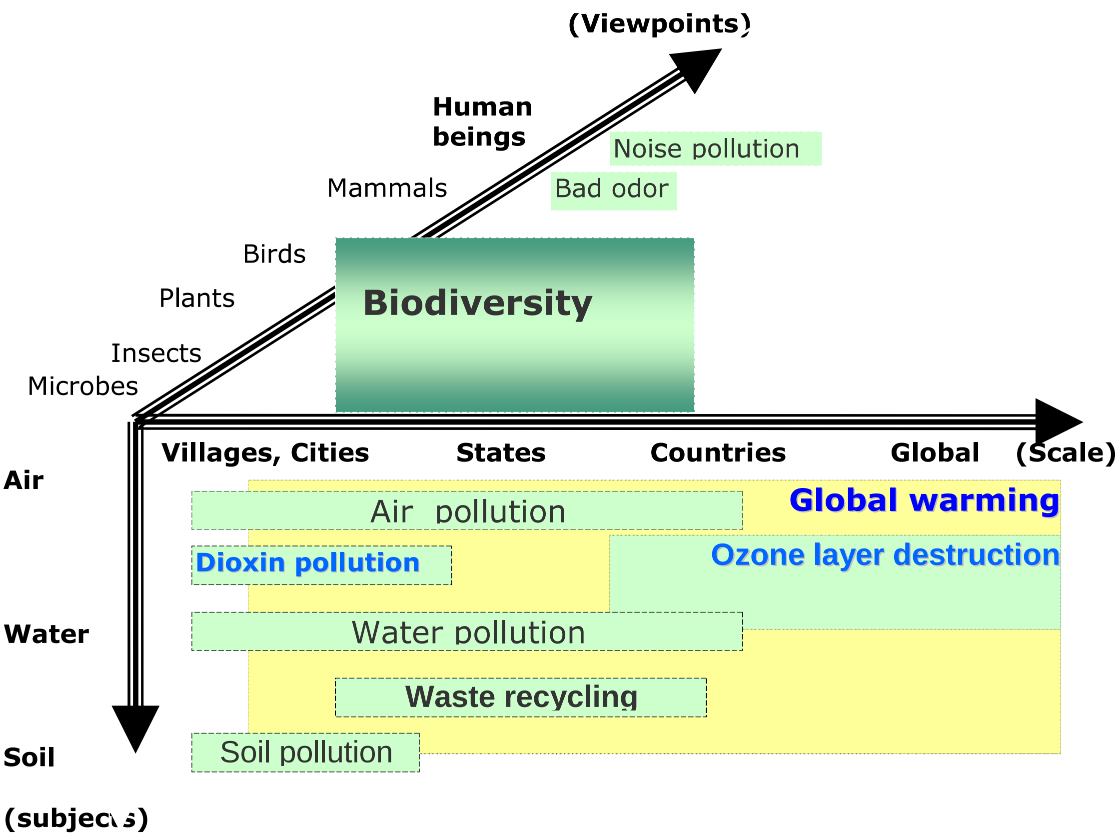

Fig 1 Relation between environmental problems and the three aspects of scale, viewpoints, and subjects

Then we studied the rate of occurrence of global warming, ozone layer destruction, and waste recycling. The Japanese-specific environmental problem of dioxin pollution was also studied.

We analyzed the rates of occurrence using a statistical method.

Next we studied the case of ozone layer destruction and related countermeasures as an example in which it is widely thought that countermeasures have been effective. In this study, we analyzed newspaper articles by what we will refer to as the grouping method, which is also known as the affinity diagram method, and generated the flow of government policy, environmental problem, and environmental countermeasures by companies.

Finally, we studied public opinion as investigated by the Japanese government[6].

3. Rate of occurrence of environmental problems in Japanese newspaper information articles:

The rates of occurrence of selected environmental problems were as showed in Fig. 2.

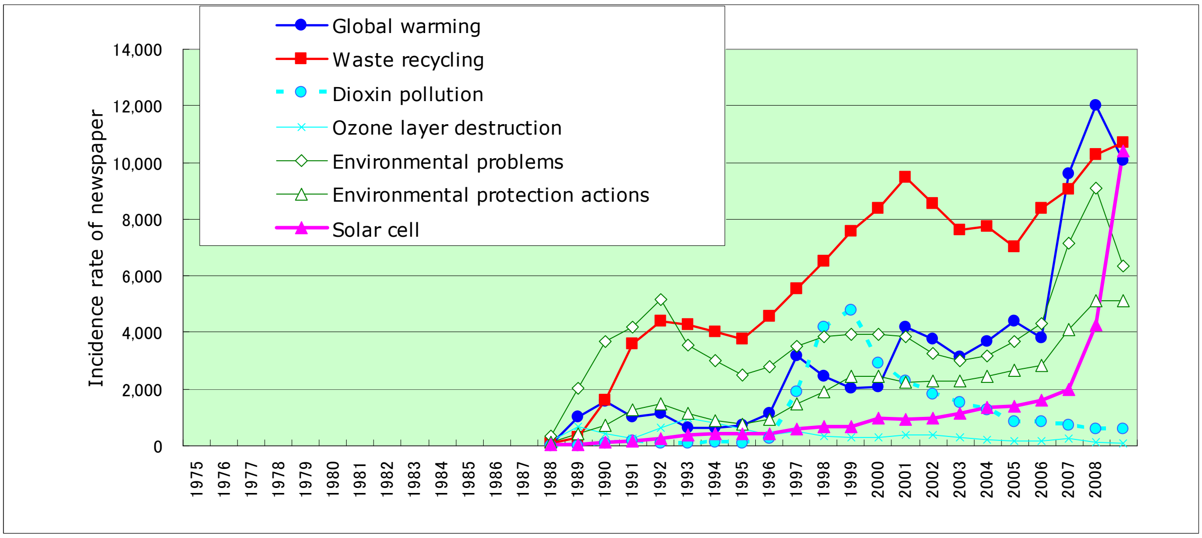

Fig. 2 Rates of occurrence of environmental problems and environmental protection actions in Japanese newspaper articles

The relation between environmental problems and each environmental problem was investigated by correlation coefficients. Correlation coefficients were investigated over periods ranging from 1 to 6 months. The most suitable period was 6 months. Maximum correlation coefficient was obtained for a 6-month period. Newspaper articles were summarized with using 6-month periods. The results were as shown in Fig. 3

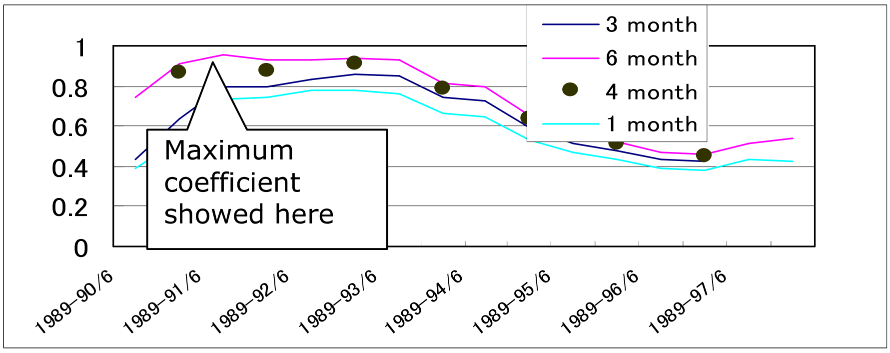

Fig. 3 Period for maximum correlation coefficient. (As an example: Waste recycling)

These results are summarized in Table 1.

Table1 Notable environmental problems and a half life

Relation	Maximum R^2 term	Correlation coefficient(R^2)	Half life
Environmental problems – **Ozone layer destruction**	**1988–89/6**	0.9853	2.5 years (1st)
Environmental problems – **Waste recycling**	**1989–91/6**	0.8818	**4.5 years** (2nd)
Environmental problems – **Global warming**	**1995–97/6**	0.9941	2.5 years (1st)
Environmental problems – **Dioxin pollution**	**1996–99/6**	0.8422	**1.5 years** (1st)
Environmental protection action – **Ozone layer destruction**	**1988–89/6**	0.8890	1.0 year (1st)
Environmental protection action – **Waste recycling**	**1989–91/6**	0.9588	**4.5 years** (2nd)
Environmental protection action – **Global warming**	**1995–97**	0.9395	2.5 years (1st)
Environmental protection action – **Dioxin pollution**	**1996–99/6**	0.9460	2.5 years (1st)

Table 1 shows that notable environmental problems are changed in the following sequence.

1. Ozone layer destruction in the period 1988-89/6
2. Waste recycling in the period 1989-91/6
3. Global warming in the period 1995-97/6
4. Dioxin pollution in the period 1996-99/6

The "half-life" of the dioxin pollution problem was 1.5 years, the "half-life" of waste recycling problem was 4.5 years.

Given the above, we considered the following hypotheses to the features of environment problems.

Hypothesis 1: The period of awareness of some specific environmental problems was shorter than that of other environmental problems. We believe that this phenomenon occurs without regard to actual environmental problems.

The tendency that environmental problems exhibited the period of awareness was shown by the autocorrelation of each environmental problem. The result of autocorrelation of each environmental problem is shown in Fig. 4. This result was obtained using JUSE Statworks.

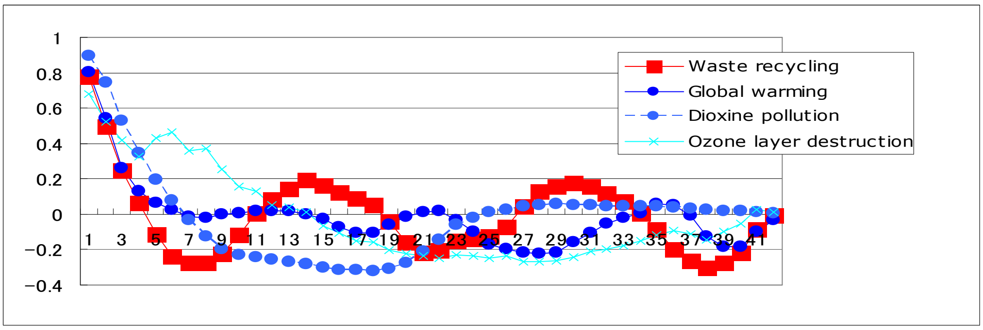

Fig. 4 Autocorrelation of each environmental problem (using JUSE Statworks)

This result seemed to show that environmental problems have the periods of awareness.

The reasons we considered that environmental problems exhibited the period of awareness were as follows.

Reason 1: The environmental countermeasures were completed.

Reason 2: Public interest in the environmental problems decreased.

Given that the environmental problems have not been essentially and completely solved up until now, we would suggest that the reason that environmental problems have the periods of awareness appears to be reason 2. Fig. 5-1 and Fig. 5-2 show, respectively, the ratio of the number of companies and proportion of pages mentioning each environmental problem in CSR reports.

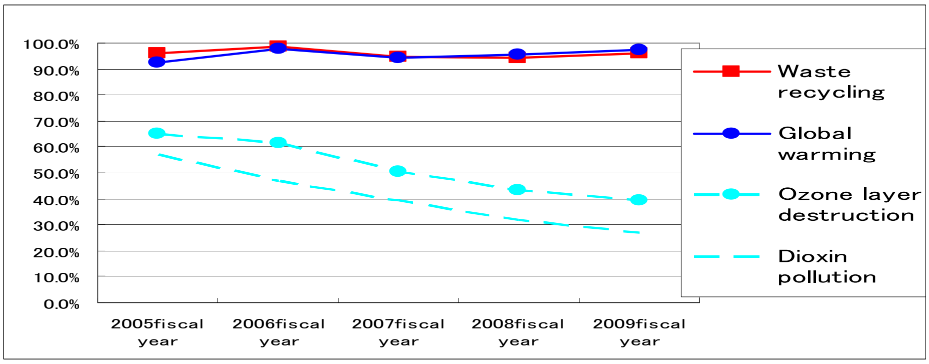

Fig. 5-1 The ratio of number of companies mentioning each environmental problem in their CSR reports.

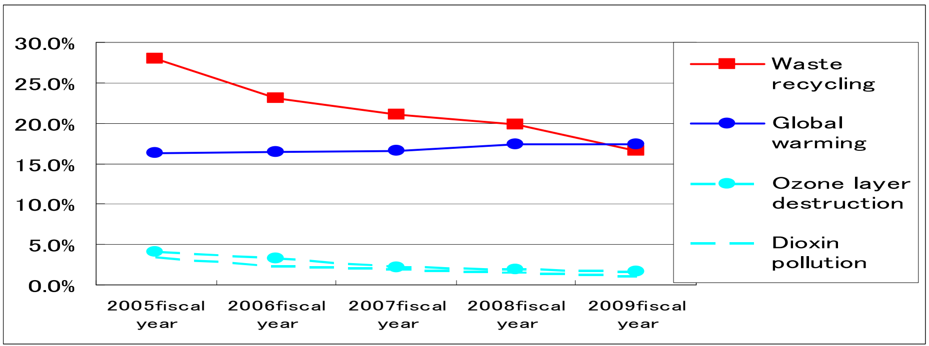

Fig.5-2 The proportion of pages mentioning each environmental problem in CSR reports.

The ratios of the number of companies mentioning each environmental problem in their CSR reports for ozone layer destruction and for dioxin pollution decreased. The ratio of the number of pages mentioning each environmental problem in CSR reports for waste recycling decreased even further. These results seem to show that public interest in some environmental problems decreased. We considered that this is a one reason of public interest decrease. But some information indicated that that newspapers stir up public interest in the dioxin pollution problem[7]. So a second reason for the decline in interest by the public was simply a decrease in interest because newspapers no longer dealt with the problem.

Hypothesis 2: Since time is required for the establishment of countermeasures for an environmental problem, it lags behind appearance of the problem in newspapers. For example, the rate of growth in the occurrence of solar cells as a countermeasure to global warming in Japanese newspapers required 10 years after the rate of occurrence of global warming as a problem grew in Japanese newspapers, and we sense that there are problems with the implementation of countermeasures.

Table 1, however, does not support this result. Given this, we investigated the rate of occurrence of newspaper articles and the moving average of environmental problems and environmental countermeasure actions. The results are shown in Fig. 6-1, Fig. 6-2, Fig. 6-3, and Fig. 6-4.

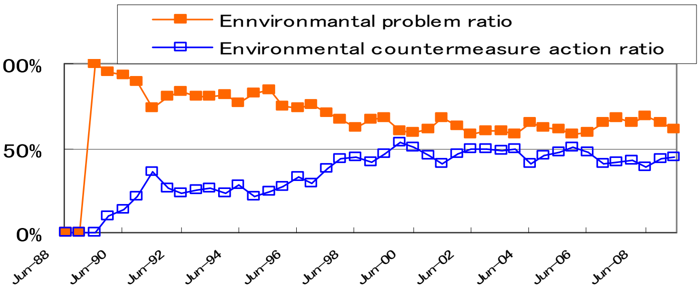

Fig. 6-1 Rates of occurrence of waste recycling in newspaper articles as an environmental problem and as an environmental countermeasure action.

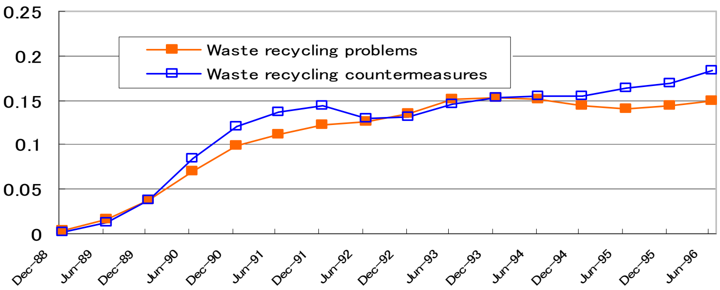

Fig. 6-2 Moving averages of waste recycling in newspaper articles as an environmental problem and as an environmental countermeasure actions.

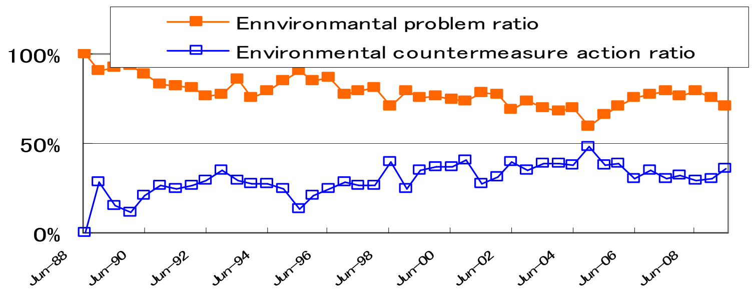

Fig. 6-3 Rate of occurrence of global warming in newspaper articles as an environmental problem and as an environmental countermeasure action.

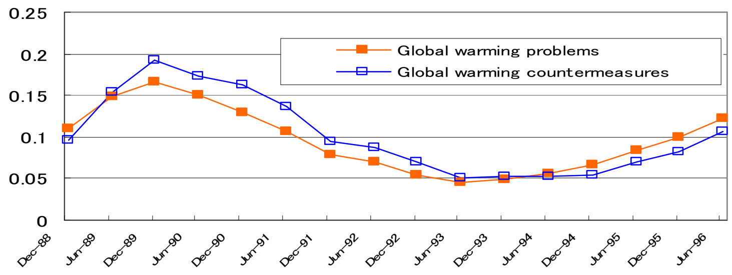

Fig. 6-4 Moving averages of global warming in newspaper articles as an environmental problem and as an environmental countermeasure action.

These results seem to support hypothesis 2.

4. Flow of environmental problems and environmental protection actions in the case of ozone layer destruction

Next we study the case of ozone layer destruction, in which it is widely thought that countermeasures have been effective. The flow of "politics," "phenomenon" of ozone layer destroy problem, and "countermeasure action by companies" was obtained by newspaper article grouping, which is also known as the affinity diagram method.

Although our first investigation was conducted before the above-noted grouping, the actual grouping was as follows.

1. "Phenomenon" Ozone hole observation.
2. "Theory" Dr. Roland pointed out the possibility of an ozone hole in 1974.
3. 1st "Investigation for policy" Preparation for discontinuation regulation of specified chlorofluorocarbons (CFCs).
4. "Countermeasure action by company 1" Chlorofluorocarbon (CFC)-replacing material development, production, and usage.
5. "Countermeasure action by company 2" No Chlorofluorocarbon (CFC) production and usage.
6. "Policy 1" Recovery of specified chlorofluorocarbons (CFCs)
7. "Countermeasure action by company 3" Recovery of specified chlorofluorocarbons (CFCs)

The results are shown in Fig. 7.

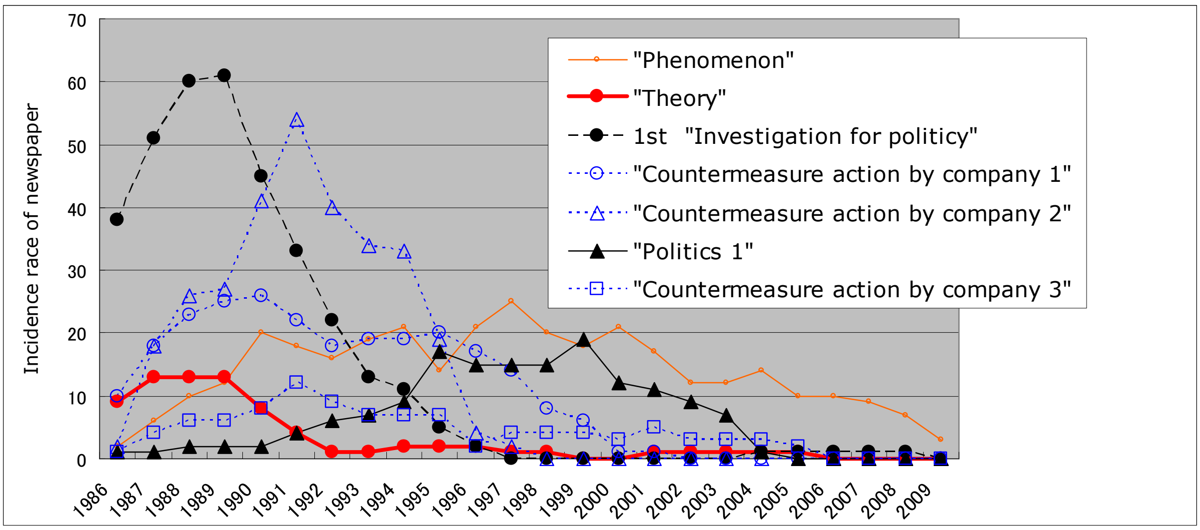

Fig. 7 Ratio of occurrence in newspaper articles after grouping.

In the case of the ozone layer destruction, we found that preparation of policies was started after the theory informed but before the phenomenon of the environmental problem occurred. The theory of Dr. Roland was reported before the ozone hole occurred. Dr. Roland's theory was correct. This tendency seemed to be important for establishing countermeasures for environmental problems.

Further we investigated public opinion by Japanese government. The results have been related to environmental protection actions by companies.

5. Results and discussion

We concluded that the following hypothesis seems to be supported by the study.

Hypothesis 1: The period of awareness of some specific environmental problems was shorter than that of other environmental problems. We believe that this phenomenon occurs without regard to actual environmental problems.

The tendency for environmental problems to have the periods of awareness was demonstrated by autocorrelation of each environmental problem. The result of autocorrelation of each environmental problem is shown in Fig. 4. This result was obtained using JUSE Statworks.

The flow example of environmental problems and environmental protection action was shown for the case of ozone layer destruction. In this study we consider that good theory of environmental problems and public opinion may affect the acceleration of environmental protection actions. The effect of good theory and public opinion will implement on global warming, dioxin pollution and waste recycling will be studied in the future and, after that study, we will show the factors of resonance in emergence action for environmental protection actions.

REFERENCES

1) Takejirou Sueyoshi, KANNKYOUKENNKYUU, vol151, No.6, (2009), pp62-71 (in Japanease)
2) http://t21.nikkei.co.jp/public/guide/index.html?gclid=CJ-D1oT7mqECFQTDbwodo37WNA
3) http://www.elnet.co.jp/member/index.html
4) Kazuhiro Kagata, Kwansei Gakuin policy studies review vol.8,(2007), pp.71-89 (in Japanease)
5) http://www.env.go.jp/press/file_view.php?serial=1106&hou_id=1599
6) http://www8.cao.go.jp/survey/index-all.html
7) Junichi Hamada, Yasuhiko Tajima, Keiichi Katsura, "Shinbungaku", Nihon Hyouronsha, (2009) (in Japanese)

SECTION 8 – Management of the Customer-Supplier Relationship

”PRODUCT VALUE” AS BOUNDARY OBJECT IN MARITIME SUPPLY

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INTRODUCTION

In a special issue of Journal of Operations Management Ketchen and Hult (2007) recommend using concepts from sociology and organisational science to develop logistics/supply chain management (SCM). In this study a mixing of concepts and approaches is carried out to develop understanding features regarding bonding actors to secure responsive supply. The key concept involved in this study is "product value". This concept is approached as a "boundary object" interlinking value provision from product supply with product user needs. The development of this conceptual use is anchored in a case study from the Norwegian maritime ship construction industry. The conceptual development is accordingly mainly related to project-oriented physical-product supply.

THE RESEARCH PROBLEM AND A PROPSED APPROACH

The current rapidly globalising marketplace is becoming an increasingly volatile space to do business within. This demands according to Christopher and Peck (2004) the development of approaches for managing in this continually fluctuating environment. The market represents an immediate environment of logistics. Environmental complexity refers to "...the number and dissimilarity of external elements relevant to an organisation's operations" (Daft 2007). Focusing on complexities of product supply involves taking closer consideration of the fragmented details and changing nature of logistics operations in conjunction with uncertainty in logistical environments. This is opposed to simplification manifest in operations research approaches to developing logistical efficiency.

"Uncertainty" represents a core concept in the field of logistics management; a phenomenon that emerges when a decision-maker experiences lack of information to predict external changes (Daft 2007, p. 55). The dominant approach to solving this need for predictability in logistics has been to plan. However as Loasby (1998) points out: "Close attention to recipes does not ensure excellent results, and even detailed manuals often make crucial, if unconscious, assumptions about the user's skills. It is notorious that standard operating procedure, followed to the letter, produce unsatisfactory levels of performance…". Use of plans is never an instant recipe for success. However, the problematic nature of using plans in a volatile marketplace does not render plans worthless. It is rather the role of plans as a component in a complex network that needs to be elaborated upon.

All industry encounters at least some degree of uncertainty. The need for responsiveness is based in adapting to fluctuations in the environment. This involves much more than simply developing market-orientation. An organisational environment is multiplex. According to Daft (2007, p.51) the task environment of an organisation may be classified as consisting of: 1) the industry sector, 2) raw materials sector, 3) human resources sector, 4) financial resources sector, 5) market sector, 6) technology sector, 7) economic conditions sector, 8) government sector, 9) sociocultural sector, 10) international sector. Duncan (1972) points to that the degree of uncertainty is impacted by two variables: 1) degree of environmental change and 2) degree of environmental complexity. In this framework it is especially business actors experiencing unstable and complex environments that experience the greatest degree of uncertainty and therefore need to develop competence in handling this uncertainty. For a supplier in a stable and simple environment long-term optimising of operations through planning may work relatively well.

Supply uncertainty is through operations research sought tamed by theories of chance; probability analysis. In this study however, uncertainties are not sought tamed or turned into a planned entity. Rather, the adaptability of the logistics system is studied through focusing on the nature of the components this system consists of and how these components interact. The complexity of a logistical system is here understood primarily from a baroque interpretation, referring to atoms in turbulent motion (Kwa 2002). This is opposed to a more romantic view found in cybernetics where natural "laws" govern pattern-making in nature. From a romantic perspective of "complexity" a holistic picture of e.g. a logistical system or supply chain is possible to attain. However, from a baroque perspective complexities in efficiently managing logistics operations direct attention to the more micro-level of interaction through knowing the features of the logistical components and how these interact. According to Kwa (2002), from a baroque perspective of complexity: "If patterns exist at all, they are short-lived"(ibid. 2002).

Given a high degree of uncertainty companies need to develop competence in manoeuvring in this untamed environment. Open systems thinking represents a stepping stone in coping with externalities. However, open systems may become extremely complex rendering e.g. SCM very challenging. An alternative mode to handle interaction with the environment in order to reduce uncertainty is based on resource dependency theory. This is an approach that postulates that organisations strive to acquire control over external resources to reduce dependency (Pfeffer and Salancik 1979, Ulrich and Barney 1984). This provides a framework for understanding the aspect of purpose when firms interact with their environment. In addition, this approach increases precision in dealing with the environment. The resources in question are identifiable whether they are physical or immaterial. IMP network thinking (Håkansson and Johanson 1993), based upon resource dependency theory, discerns between a company's supply-related "context" and a wider "environment". A supplier-customer relationship is accordingly one of a many interactions a company has with its environment. However, this is a "business relationship" which, according to the IMP network approach may be conceived as a resource independent of individual firms (or "actors")involved in this interaction (Håkansson and Snehota 1995). The sum of a company's business relationships accordingly represents its "context". A notion of business relationships as a tool to reduce uncertainty in relation to an unruly environment is evoked.

TOWARDS AN ANALYTICAL FRAMEWORK

In 1972 Richardson commenced his then largely overseen article "The Organisation of Industry" with the words: "I was once in the habit of telling pupils that firms might be envisaged as islands of planned co-ordination in a sea of market relations". Markets are by Richardson (1972) viewed not as orderly phenomenon such as commonly envisaged in neoclassical economic theory. Purchasing and sales functions, inter-organisational functions stretching the boundary of the firm, represent accordingly complex institutional arrangements involving usually a number of different actors that produces a vital informational element; direction for offerings and supply embedded in a business relationship context. This illustrates an aspect of how business relationships may be viewed as resources through coordinating internal resources with supply and demand in a relatively orderly manner.

According to Thompson (1967), the traditional approach to coping with uncertainties is through buffering. Different types of buffer resources (represented e.g. by the preceding classification of environment types) create slack and protect the company from its environment. This represents a transformation-based perspective of operations (Koskela and Vrijhoef 2001). This presupposes that the individual processes are independent of each other; that efficiency is sought though optimising a series of such sub-processes. This view of supply was later confronted by a flow view. Miller (1922) states that "...there must be avoidance of the large industrial wastes that come from overloaded inventories; slow movement of materials through successive operations of manufacturing...". A flow view of supply involves integrating with notions of an individual efficiency, the efficiency of both preceding and following operations. Lean manufacturing employs this flows view to reduce waste through a continuous human-resource-oriented development (e.g. Womack et al. 1990, Liker 2004). In addition SCM (e.g. Lambert et al. 1998) encompasses this flows-oriented view of product supply. The flow concept applied in SCM directs accordingly managerial focus to seeking value provision as a collective responsibility of all actors involved in managing and operation a flow of goods.

From marketing channels literature product supply is pictured by Alderson (1965) through his transvection model as a sequence of product transformations coordinated with the purpose of quality product placement in the hands of an end-user. The concept of "purpose" in Alderson's (1965) supply-oriented framework (the transvection) is interwoven with end-user perceptions. ; an early form of "value-orientation" in product supply literature. The transvection is also in line with the then recently developed marketing concept (Shaw and Brian Jones 2005).

Within lean manufacturing the conception of providing customer value gained increasing importance. This is reflected through that flows of goods should be order-driven rather than plan-driven. From this perspective the business relationship between the supplier and end-user gains importance. From an IMP network perspective this linkage between the supplier and customer is not only embedded in a more or less complex and unstable environment; each business relationship interacts with other business relationships in a network context (Håkansson and Persson 2004). In a task environment endowed with a high degree of uncertainty a supplier must form a managerial viewpoint strive to achieve responsiveness; a pull-based flow of goods. The challenge here is aligning customer perceptions of value with value provided through a sequentially organised chain of supply related activities in physical distribution. In this study these thoughts regarding aligning the customer with multi-tier supply through a "chain" or "network" structure are sought illustrated with examples for the maritime industry.

The maritime industry consists from a supply chain perspective traditionally of four main groups of actors: 1) Components and materials suppliers, 2) Ship product suppliers, 3) Ship yards, and 4) Ship owners. The shipyard is in practice a builder of the hull of the ship and the basic steel constructions of the ship. Ship product suppliers design, manufacture, install and commission advanced ship products. Shipbuilding in the yard resembles processes in the construction industry (Koskela and Vrijhoef 2001) in that each product (a ship) is more or less a unique product. Peculiarities of shipbuilding involve scheduling timely arrival of parts through a construction *project* in a prolonged time-period. Component suppliers again coordinate production and delivery with upstream-tier suppliers. Furthermore the "focal" (the actual case) supply is coordinated with a different service providers such as banks, logistics companies, ship designers, and government; a supply network consisting of different interacting business relationships.

The concepts of "boundary object" and "boundary spanner" are introduced to visualise how business relationships may be regarded as entities where value provision through supply interacts with customer needs; potentially managerial tools that may be used to improve responsiveness in shipbuilding and construction in general. According to Star and Griesemer (1989): "Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable means of translation. The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds". Product value is an ideal type of boundary object. "Boundary spanners" create linkage through information exchange with "boundary objects", creating shared meaning across "boundaries"; dynamics linking people in organizations, across "boundaries" of departments and companies (Daft 1989).

The concept of "boundary spanners" was developed primarily to reduce the dependence of buffering mechanisms between a firm and its environment. These concepts together provide a detailed framework for approaching the nature of interaction within business relationships. A specific network approach to achieve responsiveness is developed where "product value" is proposed as a focal boundary object while boundary spanners are primarily informational techniques used to create develop a common conceptualisation of "product value" in the context of a business relationship; most prominently supplier-customer relationships involved in managing and operating product supply. The next phase is to test out this approach in relation to empirical data from a business relationship involved in supply components in a ship-building process.

METHOD AND CASE

The following case narrative is based on project work in developing lean supply. This involved a series of informal interviews. In addition notes were taken of observations. This project work is continuous, and is at present still in progress. In line with lean thinking, continuous improvement ("kaizen") is being coached by the consultant who is also co-authoring this paper. Figure 1 below provides a rough overview of the activity sequence of administrative tasks and technical operations at a ship product/component supplier in Western Norway:

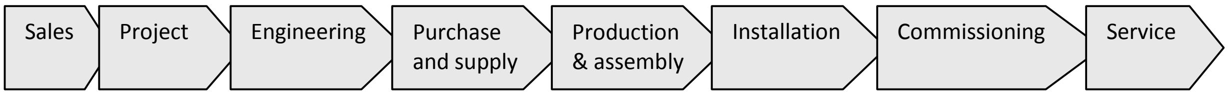

Fig .1. Sequence of administrative and technical operations from the perspective of ship product/component supplier.

Based on this overview, the individual operational components of the supply process are discussed in further detail:
The sales process has a strong customer focus involving close relations to local and global customers. Operations are characterised by an open-minded attitude and high technical competence, and a high degree of motivation to provide customers solutions adapted to their needs. Rather than being dictated by seeking manufacturing efficiencies, the sales function operates in an autonomous manner to secure customer orientation. At the time of signing a contract, this involves usually a more or less unique product that still needs to be developed in order to satisfy the customer's needs. Constructing the ship involves always some degree of uncertainty to supply in accordance with contract requirements. This uncertainty has led to creating a new department under the sales department; "the project department". The sales process is highly resource-demanding, involving long lead time and a complex and continuous information exchange.

The project process clarifies the nature of the product sold to the customer and defines the main components and component suppliers involved to fulfil the contract. Since most orders consist of some degree of new or adapted technical solutions, there is usually need for detailed engineering. Project engineers maintain contact with customers and follow the project until final delivery of the product package (ship) to the customer. This managerial process is resource demanding involving in many cases long lead times and includes a many different information components that need to be communicated within and between firms.

The engineering process clarifies the remaining undefined technical solutions with the customers providing final drawings and technical specifications. The engineering process involves often long lead-times and complex forms of information exchange. There are many informational components, and many actors involved in communicating this information over the relatively long time-period involved in constructing a ship. The engineering process can in many cases reveal what may seem to be unsolvable technical obstacles. This often leads to new discussions involving the customer in finding feasible solutions. This also impacts on the overall course of the project, the design of operations involved in constructing the ship. In some cases the customer communicates a desire to alter product specifications after the construction of the ship has been initiated. This is called a "change order" and may open for renewed contract negotiations involving the overall price, compensation for wasted labour and costs associated with altering the delivery of pre-ordered components ('long-lead items'). After these issues have been clarified the engineering process can communicate the specification to the purchasing department.

Having received the preliminary information from the project process, and the pre-ordered "long-lead item", the supplier now awaits further information concerning the continuation of the ship-building process. To reduce the lead-time the purchasing department of the supplier has in many cases forecasted the needed parts and thereby pre-ordered relatively standardised parts with alternative usage. The lead time of the standard parts is in many cases, lasting up to 18 months. This may in-part due to the cyclic nature of the business. Suppliers are sometimes tightly integrated with a focal firm while in other cases they are less integrated. Developing business relationships to secure responsiveness is time-consuming. In practice the ship-builder within the maritime industry lacks sufficient organisational resources to equally develop its various supplier relationships. This differentiation in business relationship development may be related to the complexity of information exchange in supplier relationships within the maritime industry.

The production and assembly process in the ship-building factory (ship-yard) is impacted by that every new ship is relatively unique entity. The ship construction process as a whole needs to be coordinated with supply of a vast amount of different components and parts. Production must be in line with government-regulated demands regarding traceability and quality; supported through ISO-certification. Problems and challenges emerge in this department and leading to delays in supply and thereby increased technical challenges. Under normal circumstances the resource demand is low coupled with low lead-time. However, in these normal circumstances information and communication needs are demanding. Depending on the nature of the product, test procedures can be both complex and challenging. Transport of the many components ship to the ship yard is in many cases also complex and demanding since suppliers are located all over the globe and component supply requires in many cases special transport due to their size. When these components arrive to the ship yard the supplied component is ready for installation.

The installation process at the yard is in many cases carried out under somewhat turbulent conditions. Many of component suppliers work side-by-side to complete installation of their components in the ship. In addition they this installation demands careful coordination between the different component suppliers. The component suppliers normally send their own personnel to carry out the installation process at the ship yard. This paints a scenario at the ship yard with a complex mixing of firms, persons, products, materials, languages and so on. This coordination involves a combination of simultaneously and sequentially organised activities. Furthermore, suppliers are under pressure to deliver on time. Fines measured per day pose a threat to the profitability of an individual order of a supplier. Materials and products can be damaged or go missing during installation. The safety of the installation crew can be threatened by short lead times. The installation process is accordingly prone by economic risk.

The commissioning process has characteristics similar to the installation process. In this process pressure is placed on completing production, and testing-out; thereby providing hopefully a functional ship. The ship-owner has normally contracted the ship to operations, and the loss of money can be up to 200 000 US$ per day if delivery is delayed. Should a delay occur, if applicable, this may initiate a process where the shipbuilder may seek compensation from a component supplier that is considered responsible for the ultimate delay. Accordingly, the commissioning process is costly and risky in terms of lead time and costs for the product suppliers.

DISCUSSION AND CONCLUDING REMARKS

"Change" impacts as described in the excerpts above in a decisive manner on technical processes due to arrange of different operational-level uncertainties. However, operations are always adapted and coordinated in ship-building to a unique ship design. Shipbuilding involves accordingly project-oriented organisational structure where operations are tailored. Fundamentally different products are assembled at the shipyard in a certain sequence. In addition, the large number of components, actors and long time frame involved increases complexity. Shipbuilding is prone to uncertainty. Therefore we propose that supply development should direct logistical focus to improving responsiveness in product supply. This responsiveness cannot, however be limited to developments in a single "focal" business relationship. Supply carried out in one business relationship must be coordinated with supply from other business relationships. Coordination involves both vertical and horizontal dimensions of activity coordination measurable at the shipyard. Therefore a network approach is demanded.

The concept of "product value" is important in this network setting. In each business relationship suppliers need to develop understanding of both how they may provide product value. In addition, customer orientation demands that the supplier learns through interaction the nature of customer perceptions of product value. A conception of what constitutes of logistics quality in a specific business relationship context must be developed among suppliers and customers. This development represents a collective endeavour carried out in the business relationship involving a set of different boundary spanners; organised information exchange through e.g. personal contacts, telephone, and documents. However, this essentially technical boundary spanning is impacted by the organisational collective of end-users, designers, and other suppliers. Evoked complexity increases here as the number of sources for potential change in what constitutes "product value" in a specific business relationship is pointed out. "Product value" is accordingly a dynamic phenomenon involving a range of different perceptions. In its role as boundary object to secure responsiveness by interlinking customer needs with technical supply, boundary spanners must be technically organised in manner that is flexible enough to encompass the dynamics of continuously developing what constitutes "product value" in a specific product supply process. This demands a network view where boundary spanners are developed and interlinked between a set of different business relationships. In addition, the various suppliers are each partakers in different supply chain, meaning that coordination in accordance with SCM principles in one chain must be aligned with that of other supply chains. Using "product value" to cope with uncertainty in a construction process is illustrated in figure 2 below:

Figure two: the network of business relationships impacting on conceptions of "product value" at the ship-yard.

"Product value" represents primarily in figure two perceptions of the ship yard. Furthermore, figure two depicts the collective of supply relationships as context of "product value" where product value represents a conceptual node in a network of different actors and perceptions impacted by boundary spanning. This creation of logistical meaning is embedded in a context where actor bonding takes place; a setting characterised by the network atmosphere. In this picture "product" value" as boundary object represents an organisational objective. In the context of a focal business relationship actors should strive to develop the content what constitutes "product value". Boundary spanners are the tools to develop this agreement. In addition perceptions of product value developed in one business relationship interact with similar perceptions of product value developed in other interfacing supply, support and customer relationships. A need to coordinate these perceptions is evoked. This underpins a focal role of the shipyard as a focal actor or "channel captain", a role here mainly concerned with mediating between different perceptions regarding product value. Further empirical studies may direct attention to the different levels of achieving consensus regarding perceptions of "product value". This involves studies at the intra-firm, business relationship and network level. Notions of network centrality/identity and atmosphere may be considered in how these impacts on developing common logistics meaning including to what degree consensus regarding what constitutes product value may be achieved.

REFERENCES:

Alderson W (1965) "Dynamic Marketing Behavior. A Functionalist Theory of Marketing", Homewood IL: Richard D. Irwin.

Christopher M and Peck H (2004) "Building the Resilient Supply Chain", The International Journal of Logistics Management, Vol. 15 No. 2, pp.1-13.

Daft RL (1989) "Organization Theory and Design" (3rd ed.), New York: West Publishing Co.

Daft RL (2007) "Understanding the Theory and Design of Organizations", Masin, OH: Thompson Southwestern.

Duncan RB (1972) "Characteristics of Perceived Environments and Perceived Environmental Uncertainty", Administrative Science Quarterly. No. 17:313-327.

Håkansson H and Johanson J (1992) "A Model of Industrial Networks", in B. Axelson and J. Easton, eds. Industrial Networks: A New View of Reality, London: Routledge.

Håkansson H and Snehota I (1995) "Developing Relationships in Business Networks", London: Routledge.

Håkansson H and Persson G (2004) "Supply Chain Management: The Logic of Supply Chains and Networks", The International Journal of Logistics Management, Vol. 15, No. 1, pp. 11-26.

Jahre M, Gadde L-E, Håkansson H, Harrison D and Persson G (2006) "Resourcing in Business Logistics - The Art of Systematic Combining", Lieber AB, Sweden.

Ketchen DJ and Hult GT (2007) "Bridging organization theory and supply chain management: The case of best value in supply chains", Journal of Operations Management, Vol. 25, pp. 473-480.

Koskela L and Vrijhoef R (2001) "Is the current theory of construction a hindrance to innovation?", Building Research & Information, Vol. 29., No. 3, pp. 197-207.

Kwa C (2002) "Romantic and Baroque Conceptions of Complex Wholes in the Sciences", in Law J and Mol A, Complexities, Social Studies of Knowledge Practices, Durham, NC: Duke University Press.

Lambert DM, Cooper MC and Pagh JD (1998) "Supply Chain Management: Implementation Issues and Research Opportunities", The International Journal of Logistics Management, Vol. 9, No.2,1-19.

Liker JK (2004) "The Toyota Way", New York:McGraw Hill.

Loasby BJ (1998) "The Concept of Capabilities", in Foss NJ and Loasby BJ (eds.) Economic Organization, Capabilities and Co-ordination, Essays in Honour of G.B. Richardson, Routledge, London, UK.

Miller JK (1922) "Prevention of Wastes in Industry", Mechanical Engineering, Jan.2000 ed.:9-10, 42.

Pfeffer J and Salancik G (1978) "The External Control of Organizations: A Resource Dependent Perspective", New York: Harper Row.

Richardson GB (1972) "The Organization of Industry", The Economic Journal, September: 883-896.

Ulrich D, and Barney JB (1984) "Perspectives in organizations: Resource Dependence, efficiency, and Population". Academy of Management Review. No. 9: 471-481.

Shaw EH and Brian Jones DG (2005) "A History of Schools of Marketing Thought", Marketing Theory, Vol. 5, No. 3: 239-281.

Star SL and Griesemer JR (1989) "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39". Social Studies of Science. 19 (4): 387–420

Thompson JD (1967) "Organizations in Action". New York: McGraw Hill.

Womack JP, Jones DT and Roos D (1990) "The Machine that Changed the World: The Story of Lean Production", New York: Rawson Associates.

AN ANALYSIS OF THE RELATIONSHIP BETWEEN INTEGRATION PRACTICES AND SUPPLY CHAIN ORIENTATION

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ABSTRACT
An increase in the level of supply chain integration is often regarded as one of the main factors to improve the firm's performance. The impact of supply chain integration on supply chain performance has been studied by many authors. However, this study explored the relationship between integration practices (internal and external firm integration) and six dimension of supply chain orientation: (customer orientation, competitor orientation, supplier orientation, logistic orientation, operation orientation and value chain coordination). Based upon survey data 400 respondents from 70 consumer goods companies in South Sumatera Indonesia, 248 were considered as valid. The results show that internal and external firm integration is partly related to supply chain orientation component. However, Firm-customer integration is predictor of the customer orientation, competitor orientation, logistic orientation, operation orientation and value chain coordination

INTRODUCTION
Supply chain linkages actors collectively convert raw inputs into finished products (Mabert and Venkataraman, 1998). Some of these links cross-border companies, while others remain in one company. Superior supply chain has created a significant advantage over their competitors (Boyer *et al*., 2004; Hult *et al,* 2008). On the other hand, poor supply chain management often have serious negative consequences. For example, a study recently revealed that was the emergence of major supply chain problems usually reduce the company's shareholder value by more than ten percent (Hendrick and Singhal, 2003; Hult *et al.,* 2008).

The impact of supply chain integration on supply chain performance has been studied for some time. However, this research intent to explore the relationship between internal and external firm integration and supply chain orientation in the South Sumatera Indonesia consumer goods industry.

THEORITICAL BACKGROUND
Integration is a broad term that can be used to explain the various relationships between departments and companies. For example, internally and externally, companies can integrate elements of their operations differently. These elements became evident (such as product flow, measurements, etc.) or intangible (such as relationships, information, etc.). Potential broad topic of integration not only offers a wealth of knowledge but also introduces many complications. Managers may question what kind of integration should be focused on, what action should be taken, when various types of overlapping integration, and what procedures should be followed.

The company currently faces many competing priorities in a global economy. Culture has been shown to be associated with performance (Denison & Mishra, 1995). Companies must learn how to integrate both internally and externally, with customers and suppliers. Integration efforts are very important for lean initiatives in which cooperation and coordination with both customers and suppliers is an important and necessary (Shah *et al.*, 2002; Womack & Jones, 1996

Integration practice is divided into two categories: internal and external integration. Integration of internal company practices fall within the limits of integration between the company and include functional and inter-departmental. External integration practices happening outside the traditional boundaries of the company and includes the coordination and cooperation with customers and suppliers (Braunscheidel, 2005).

External integration is the integration of a company with key suppliers and customers (Lambert *et al.,* 1998; Lambert *et al*, 1996.). It empirically showed that there is a high correlation between the practice of integration with suppliers and customers and company performance (Frohlich & Westbrook, 2001; Rosenzweig *et al*., 2003). There is also a growing recognition that individual businesses no longer compete as stand-alone entity but rather as supply chains (Chandrashekar, 1999; Christopher, 2000)

A business philosophy may differ from the more management-term action-oriented. Therefore, Mentzer *et al.* (2001) proposed the term supply chain orientation (SCO), the idea of seeing the coordination of supply chain from the perspective of the overall system, with each flow distribution tactical activity seen in the context of the broader strategic terms to replace the SCM as a management philosophy. Supply chain orientation is thus, defined as recognition by the organization system, strategic implications of tactical activities involved in managing the various flows in a supply chain (Mentzer *et al.* 2001). If management can see the implications of the management of upstream and downstream flows of products, services, finance, and information on all suppliers and their customers, a company has a supply chain orientation. Conversely, companies do not have a supply chain orientation, if only to see the system, strategic implications in one direction (i.e. both upstream and downstream from the channel). Hult, *et al* (2008) proposed six indicator of supply chain orientation: (1) customer orientation, (2) competitor orientation, (3) supplier orientation, (4) logistic orientation, (5) operation orientation and, (6) value chain coordination.

CONCEPTUAL MODEL

This study examines the relationship between firm integration and supply chain orientations. Based on the study's objectives, the following three hypotheses will be tested:

H_1a-H_1f: *There is a relationship between internal firm integration and supply chain orientation (customer orientation, competitor orientation, supplier orientation, logistic orientation, operation orientation, and value chain coordination).*

H_2a-H_2f: There is a relationship between firm-supplier integration and supply chain orientation (customer orientation, competitor orientation, supplier orientation, logistic orientation, operation orientation, and value chain coordination).

H3a-H3f: There is a relationship between firm-customer integration and supply chain orientation (customer orientation, competitor orientation, supplier orientation, logistic orientation, operation orientation, and value chain coordination).

METHODOLOGY

Our main focus is to investigate the relationship between internal and external firm integration and supply chain orientation in the South Sumatera Indonesia consumer goods industry; we used judgmental sampling or purposive sampling, so our target population was owners, president/CEO, and vice president, director, manager and senior staffs. From 400 questionnaires were distributed, 248 completed questionnaires were returned, giving a response rate of 62%. Data collection took place from March to July 2009.

RESULTS

The Cronbach's alpha was conducted to assess the reliability of each scale. Alpha values over 0.7 indicate that all scales can be considered reliable (Nunally, 1978). For each of the item scales, factor analysis was used to reduce the total number of items to manageable factor. Principal components analysis is used to extract factors with eignevalue greater than 1. Varimax rotation is used to facilitate interpretation of the factor matrix. Sampling adequacy measurement tests are also examined via the Kaiser-Meyer-Olkin statistics to validate use of factor analysis.

Table 1 shows the results from factors analysis. The KMO value of 0.831 indicate sampling adequacy. The factor model indicates three distinct factors loading without any misclassification: internal firm integration, firm-supplier integration and firm-customer integration. Cronbach's alphas among 20 items in the questionnaires exceeded 0.7. Seven items are identified for internal firm integration (IFI) and firm-customer integration (FCI), respectively, and six items for firm-supplier integration (FSI). These items are treated as independent factors.

Table 1 Summary for factor analysis for IFI, FSI and FCI

Items	IFI	FSI	FSI
Integrated database (IFI1)	0.521		
Easy access to key operational data (IFI2)	0.365		
Highly integrated information system (IFI3)	*0.650*		
Access to inventory levels in our supply chain. (IFI4)	0.436		
Retrieve inventory status in real time (IFI5)	0.683		
Computer-based planning system between marketing and production (IFI6)	0.579		
High degree of information system integration for production processes (IFI7)	0.522		
Strategic linkages with suppliers in our supply chain (FSI1)		0.576	
Involves suppliers during the design stage for our new products (FSI2)		0.657	
Involves suppliers in production planning and inventory management (FSI3)		0.571	
Rapid response ordering processing system with our suppliers (FSI4)		0.526	
Our company has a supplier network that assures reliable delivery (FSI5)		0.702	
Uses information technology well to exchange information with suppliers (FSI6)		0.583	
Shares product information with customers electronically (FCI1)			0.731
Accepts customer orders electronically (FCI2)			0.708
Interacts with customers to forecast demand (FCI3)			0.711
Order placing system that is fast and easy to access (FCI4)			0.652
Shares order status with customers during order scheduling (FCI5)			0.734
Shares order status with customers during product manufacturing (FCI6)			0.588
Shares order status with customers during product delivery (FCI7)			0.352
Cronbach's alpha	0.77	0.71	0.87
KMO (Kaiser-Meyer-Olkin) value		0.831	

A similar factor analysis was applied to the supply chain orientation areas: customer orientation (CUO), competitor orientation (COO), supplier orientation, (SUO), logistic orientation (LOO), operation orientation (OPO) and value chain coordination (VCC). Among 60 items in the questionnaire, five items are deleted during the factor analysis. A total of 55 items were reduced to six underlying factors loadings, depicted in Table 2. Cronbach's alphas among 55 items in the questionnaires are exceeded 0.7. Ten items are identified for customer orientation, eight items for competitor orientation, eight items for supplier orientation, nine items for operation orientation, ten item for logistic orientation and ten items for value chain coordination, respectively. These items are treated as dependent factors. The KMO value of 0.774 indicate sampling adequacy.

Table 2 Summary for factor analysis for supply chain orientation

Items	CUO	COO	SUO	OPO	LOO	VCC
Serve customer need (CUO1)	0.583					
Communicate information (CUO2)	0.625					
Develop value chain strategies (CUO3)	0.656					

Measure customer satisfaction (CUO4)	0.731					
Disseminate data (CUO5)	0.670					
Help customer (CUO6)	0.648					
Discover customer need (CUO7)	0.601					
Seek opportunities (CUO8)	0.622					
Recognize customer need (CUO9)	0.727					
Extrapolate key trend (CUO10)	0.659					
Communicate information about competitor (COO1)		0.727				
Develop value chain strategies based on understanding of competitor (COO2)		0.634				
Assess competitor systematically and frequently (COO3)		0.791				
Disseminate data on competitor at all levels on a regular basis (COO4)		0.581				
Understanding competitor to be prepared for development in our market (COO5)		0.607				
Try to discover additional action of our competitor (COO6)		0.610				
Try to recognize competitor's action (COO7)		0.715				
Extrapolate key trend to understand what competitor may do in future (COO8)		0.666				
Develop supply chain strategies based on understanding of supplier (SUO1)			0.742			
Assess supplier systematically and frequently (SUO2)			0.810			
Disseminate data on suppliers at all level (SUO3)			0.689			
Understanding supplier to be prepared for development in market (SUO4)			0.760			
Try to discover additional action of supplier (SUO5)			0.562			
Seek opportunities in area where suppliers have difficulties (SUO6)			0.754			
Try to recognize supplier's action (SUO7)			0.840			
Extrapolate key trend to understand what suppliers may do in the future (SUO8)			0.797			
Constantly monitor commitment to understanding logistic activities (OPO1)				0.743		
Communicate information about logistic activities across all units (OPO2)				0.682		
Develop value chain strategies based on understanding of logistic (OPO3)				0.556		
Assess logistic activities systematically and frequently (OPO4)				0.698		

Disseminate data on logistic activities at all levels (OPO5)				0.633		
Understanding logistic activities to be prepared for market development (OPO6)				0.685		
Try to discover additional logistic (OPO7)				0.720		
Seek opportunities in area where current logistic has difficulties (OPO8)				0.724		
Try to recognize logistic possibilities (OPO9)				0.557		
Extrapolate key trends to understand what future logistic activities needs. (OPO10)				0.611		
Constantly monitor commitment to understanding operation management (LOO1)					0.536	
Communicate information about operation management activities. (LOO2)					0.736	
Develop value chain strategies based on understanding OM (LOO3)					0.656	
Assess operation management activities systematically and frequently (LOO4)					0.623	
Disseminate data on operation management activities (LOO5)					0.656	
Understand OM activities prepared for market development (LOO6)					0.684	
Try to discover additional OM possibilities (LOO7)					0.627	
Seek opportunities in areas where OM has difficult delivering. (LOO8)					0.686	
Extrapolate key trends to understanding what OM may need in future (LOO9)					0.726	
Constantly monitor coordination of value chain (VCC1)						0.711
Coordinate information about value chain activities (VCC2)						0.703
Coordinate strategies based on understanding of value chain activities.(VCC3)						0.740
Coordinate value chain activities systematically and frequently (VCC4)						0.711
Coordinate data on value chain activities at all level on a regular basis (VCC5)						0.748
Coordinate value chain activities to be prepared for market development (VCC6)						0.584
Coordinate value chain activities to try discover additional possibilities (VCC7)						0.753
Coordinate opportunities in area						0.647

where value chain has difficulties (VCC8)						
Coordinate value chain possibilities (VCC9)						0.659
Extrapolate key trends to coordinate what future value chain activities (VCC10)						0.547
Cronbach's alpha	0.85	0.82	0.88	0.86	0.84	0.86
KMO (Kaiser-Meyer-Olkin) value	0.774					

Table 3 shows the correlation between independent variables (internal firm integration, firm-supplier integration, and firm-customer integration) and dependent variables (supply chain orientation) were positive. Internal firm integration had a correlation of 0.253, $p<0.01$ with customer orientation, 0.237, $p<0.01$ competitor orientation, 0.222, $p<0.01$ supplier orientation, 0.241, $p<0.01$ logistic orientation, 0.211, $p<0.01$ operation orientation, and 0.212, $p<0.01$ value chain coordination. Which mean that the respondents are more likely to evaluate internal firm integration was positive when supply chain orientation is positive.

Firm-supplier integration had a correlation of 0.142, $p<0.05$ with customer orientation, 0.137, $p<0.05$ competitor orientation, 0.125, $p<0.05$ supplier orientation, 0.223, $p<0.01$ logistic orientation, 0.280, $P<0.01$ operation orientation and 0.164, $p<0.01$ value chain coordination.

Firm-customer integration has a correlation of 0.294, $p<0.01$ with customer orientation, 0.266, $p<0.01$ competitor orientation, 0.220, $p<0.01$ supplier orientation, 0.292, $p<0.01$ logistic orientation, 0.197, $p<0.01$ operation orientation and 0.325, $p<0.01$ value chain coordination.

Table 3 the correlation between independent and dependent variables

		1	2	3	4	5	6	7	8	9
Internal Integration	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	248								
Firm-supplier integration	Pearson Correlation	0.198**	1.000							
	Sig. (2-tailed)	0.002	.							
	N	248	248							
Firm-customer integration	Pearson Correlation	0.406**	0.202**	1.000						
	Sig. (2-tailed)	0.000	0.001	.						
	N	248	248	248						
Customer Orientation	Pearson Correlation	0.253**	0.142*	0.294**	1.000					
	Sig. (2-tailed)	0.000	0.026	0.000	.					
	N	248	248	248	248					
Competitor Orientation	Pearson Correlation	0.237**	0.137*	0.266**	0.789**	1.000				
	Sig. (2-tailed)	0.000	0.031	0.000	0.000	.				
	N	248	248	248	248	248				
Supplier Orientati	Pearson Correlation	0.222**	0.125*	0.220**	0.728**	0.765**	1.000			

on	Sig. (2-tailed)	0.000	0.049	0.000	0.000	0.000	.			
	N	248	248	248	248	248	248			
Logistic Orientation	Pearson Correlation	0.241**	0.223**	0.292**	0.767**	0.759**	0.731**	1.000		
	Sig. (2-tailed)	0.000	0.000	0.049	0.000	0.000	0.000	.		
	N	248	248	248	248	248	248	248		
Operation Orientation	Pearson Correlation	0.211**	0.280**	0.197**	0.776**	0.776**	0.742**	0.872**	1.000	
	Sig. (2-tailed)	0.001	0.000	0.002	0.000	0.000	0.000	0.000	.	
	N	248	248	248	248	248	248	248	248	
Value Chain Orientation	Pearson Correlation	0.212**	0.164**	0.325**	0.750**	0.750**	0.674**	0.789**	0.831**	1.000
	Sig. (2-tailed)	0.001	0.010	0.000	0.000	0.000	0.000	0.000	0.000	.
	N	248	248	248	248	248	248	248	248	248

*p value <0.05, **p value <0.01

The parameters of this model are estimated using multivariate regression analysis. Table 4 shows coefficients of each model along with corresponding test statistics.

In Model 1 where the dependent variable is overall supply chain orientation, the model seem to be reliable (p-value for F<0.01 and adjusted R-square of 0.120. Model 2, dependent variable is customer orientation. The model seem to be reliable (p-value for F<0.01. Firm-customer integration is the most important determinant in customer orientation with p-value for t<0.01, followed by internal firm integration with p-value of t<0.05, while firm-supplier integration is not significant with p-value of t>0.05.

Model 3, dependent variable is competitor orientation. The model seem to be reliable (p-value for F<0.01). Once again, firm-customer integration is most important determinant in competitor orientation with p-value for t<0.01, followed by internal firm integration with p-value of t<0.05, while firm-supplier integration is not significant with p-value of t>0.05.

Model 4, dependent variable is supplier orientation. The model seem to be reliable (p-value for F<0.01). It appears, internal firm integration and firm-customer integration has similar effect on the supplier orientation. Firm-supplier integration is not significant effect on supplier orientation.

Model 5, dependent variable is logistic orientation. The model also seem to be reliable (p-value for F<0.01). Firm-supplier integration and firm-customer integration have similar effect on logistic orientation with p-value for t<0.01, followed by internal firm integration with p-value for t<0.05.

Model 6, dependent variable is operation orientation. Statistically, the model also seem to be reliable (p-value for F<0.01). Firm-customer integration is strong determinant for operation orientation with p-value for t<0.01, followed by firm-supplier integration with p-value for t<0.05, while internal firm integration is not significant.

Model 7, dependent variable is value chain coordination. The model seem to be reliable (p-value for F<0.01). Firm-customer integration is strong determinant for value chain coordination with p-value for t<0.01, followed by firm-supplier integration with p-value for t<0.05, while internal firm integration is not significant.

Table 4
Model parameter estimates of supply chain orientation
(t- Value in parenthesis)
*p value <0.05, **p value <0.01

(t- Value in parenthesis)

	Model 1 Dependent variable = overall SCO	Model 2 Dependent variable = CUO	Model 3 Dependent variable = COO	Model 4 Dependent variable = SUO	Model 5 Dependent variable = LOO	Model 6 Dependent variable = OPO	Model 7 Dependent variable = VCC
Constant	116.211 (7.422)**	22.099 (7.095)**	16.214 (5.812)**	18.194 (6.481)**	19.495 (6.299)**	19.353 (7.171)**	20.857 (6.599)**
Internal integration	0.949 (2.066)*	0.206 (2.257)*	0.172 (2.101)*	0.180 (2.185)*	0.164 (1.806)*	0.112 (1.414)	0.115 (1.241)
Firm-supplier integration	1.021 (1.989)*	0.109 (1.072)	0.107 (1.172)	0.110 (1.193)	0.288 (2.833)**	0.215 (2.428)*	0.192 (1.854)*
Firm-customer integration	1.524 (3.513)**	0.277 (3.208)**	0.224 (2.901)**	0.163 (2.095)*	0.280 (3.268)**	0.240 (3.209)**	0.340 (3.878)**
Adj R2	0.120	0.099	0.085	0.063	0.123	0.101	0.108
F-value	12.253**	10.000**	8.643**	6.529**	12.569**	10.243**	10.988**

*p value <0.05, **p value <0.01

CONLUSION

Internal integration is the stage on a firm's journey to becoming fully integrated. The need to integrate internal functions is a challenge facing many organizations (Pagell, 2004). The firm recognizes that it must effectively and efficiently manage the flow of goods not only into the organization but on the way to the customer also. A stage firm is characterized by synchronizing the demand from the customer with the flow of goods in manufacturing and the flow of materials from suppliers (Stevens, 1989). Internal integration (horizontal integration within the firm) is as much a part of supply chain integration as is external integration (vertical integration) (Vickery *et al.*, 2003).

Research findings show that internal firm integration is the weakest relationship to supply chain orientation (refer to Table 4). Although internal firm integration is the weakest of the three predictors (internal firm integration, firm-supplier integration and firm-customer integration) of supply chain orientation, firms should take note that internal firm integration is important and being impact supply chain orientation. Firms must recognize that inter-functional cooperation and collaboration are critical to success. The benefits of organizing along business processes rather than functional lines have been the subject of many articles (Hammer, 2001; Hill & Scudder, 2002; Rosenzweig *et al.*, 2003). The use of cross-functional teams to solve problems and open communication among organizational members is important to the success of internal firm integration efforts. Efforts must be undertaken to eliminate barriers that exist in organizations and that keep various functions from working together to meet the needs of the customer (Pagell, 2004; Vickery *et al.*, 2003).

This study also viewed that the strongest predictor of supply chain orientation is firm-customer integration (refer to Table 4). It should be remembered that this construct is comprised of the simultaneous integration levels with both key customers and key suppliers. Frohlich and Westbrook (2001) demonstrated that firms that had the highest levels of integration with both customers and suppliers had higher performance levels than did other organizations with lower levels of integration with either or both customers and suppliers. It is not enough for an organization to be integrated with either its key customers or key suppliers. Firms must integrate concurrently with both entities in order to improve their performance. Some of the key areas within the realm of external integration are feedback on quality and delivery performance, customer sharing of demand information and the establishment of relationships at a variety of levels between the corporations.

REFERENCES

Bowersox, Donald J. and David J. Closs (1996) Logistical Management: The integrated Supply Chain Process. McGraw-Hill: New York.

Boyer, K., Hallowell, R., Roth, A. (2002), "e-Services: operating strategy: a case study and a method for analyzing operational benefits", *Journal of Operations Management*, Vol. 20 No.2, pp.175-88.

Chandrashekar, A., (1999) Toward the Virtual Supply Chain: The Convergence of IT and Organization". The International Journal of Logistics Management 10 (2), 27-39.

Christopher, M., (2000) "The Agile Supply Chain: Competing in Volatile Markets". Industrial Marketing Management 29 (1), 37-44.

Denison, D. R., & Mishra, A. K., (1995) "Toward a Theory of Organizational Culture and Effectiveness". Organization Science 6 (2), 204-223.

Frohlich, M. T., & Westbrook, R., (2001) "Arcs of integration: an international study of supply chain strategies". Journal of Operations Management 19 (2), 185-200.

G.T.M. Hult; D.J.K. Ketchen; G. L. Adams & J. A. Mena. (2008) "Supply Chain Orientation and Balance Scorecard Performance". *Journal of Management Issues; Winter 2008; 20,4;* ABI INFORM Global pg.526

Hammer, M., (2001) "The superefficient company". Harvard Business Review 79 (8), 82.

Handfield, R. B., & Nichols, E. L., (1999) "Introduction to Supply Chain Management". Prentice-Hall, Upper Saddle River,NJ.

Hill, C. A., & Scudder, G. D., (2002) "The use of electronic data interchanges for supply chain coordination in the food industry". Journal of Operations Management 20, 375-387.

Hendricks, K. B., and Singhal, V. R. (2003) "The effect of supply chain glitches on shareholder value". Journal of Operations Management, 21, 5, December 2003, Pages 501-522.

K. C. Tan, R. B. Handfield, and D. R. Krause, (1998) "Enhancing the firm's performance through quality and supply base management: an empirical study.," International Journal of Production Research, vol. 36, Oct 98

Larson and D. S. Rogers, (1998)."Supply chain management: definition, growth and approaches*," Journal of Marketing Theory and Practice, vo*l. 6, pp. 1-5.

Mabert and M. A. Venkataramanan, (1998)."Special research focus on supply chain linkages: challenges for design and management in the 21st century," Decision Sciences, vol. 29, pp. 537-552.

Mentzer, J.T., Dewitt, W., Keebler, J.S., Min, S., Nix, N., Smith, C.D., Zach, Z.G. (2001), "Defining Supply chain management", *Journal of Business Logistics*, Vol. 22 No.2, pp.1-25.

Michael J. Braunscheidel., (2005) "Antecedents of supply chain agility. A dissertation submitted to the Faculty of the Graduate School of The State University of New York at Buffalo in partial fulfillment of the requirements for the degree of Doctor of Philosophy Department of Operations Management and Strategy.

Narasimhan, R., Jayaram, J., & Carter, J. R., (2001) "An Empirical Examination of the Underlying Dimensions of Purchasing Competence". Production and Operations Management 10 (1), 1-15.

Nunnally, J (1978), *Psychometric Theory*, McGraw-Hill, New York, NY,

P.D. Larson and D.S.Rogers, (1998) "Supply chain management: definition, growth and approaches," Journal of Marketing Theory and Practices, vol. 6, pp, 1-5 fall 1998.

Pagell, M., (2004) "Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics". *Journal of Operations Management* 22.

R. Narasimhan and A. Das, (1999) "Manufacturing agility and supply chain management practices," Production and Inventory Management Journal, vol.40, pp. 4-1 0, 1999.

Robert B. Handfield , Ernest L. Nichols., (1999) "Introduction to Supply Chain Management. Prentice-Hall, Upper Saddle River,NJ.

Rosenzweig, E. D., Roth, A. V., & Dean, J., J.W., (2003) "The influence of an integration strategy on competitive capabilities and business performance: An exploratory study of consumer products manufacturers", Journal of Operations Management Vol.21. pp.437-456

Shah, R., & Ward, P. T., (2003) Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management 21 (2), 129-149.

Stevens, J., (1989) "Integrating the supply chain. International Journal of Physical Distribution and Materials Management 19 (8), 3-8.

Vickery, S. K., Jayaram, J., Droge, C., & Calantone, R., (2003" The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct vs. indirect relationships. Journal of Operations Management 21, 523-539.

Womack, J. P., & Jones, D. T., (1996) "Lean Thinking: Banish Waste and Create Wealth in Your Corporation". Simon & Schuster, New York, NY.

ATTRACTIVENESS IN CUSTOMER-SUPPLIER RELATIONSHIPS – A CASE STUDY

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ABSTRACT

A stream of literature has focused on the concept of attractiveness in buyer-supplier relationships. These studies suggest that supplier management is not merely about rational management and control but should also consider the impact of social and psychological factors, on the relationship (Ellegaard et al, 2003). The previous research has been mostly conceptual. This paper reports the results of two in-depth case studies. The paper provides practical guidance to analyzing the role of attractiveness in a supplier relationship and explains how the various elements of attractiveness are viewed by different parties of the relationship in different contexts. Finally, the paper proposes an analysis tool for practitioners to support customer-supplier relationship development from the attractiveness point of view.

BACKGROUND

Attractiveness basically means to cause interest or pleasure and to pull someone towards you by the qualities you have, especially positive and admirable ones (Cambridge Online Dictionaries). Attractiveness has been a phenomenon of study in the behavioural fields of social psychology, social exchange and organizational behaviour. It is concerned with interdependencies between social actors and focuses on the rewards and costs that individuals gain through interaction with each other. The human factor and the influence between people are often explained as having an important role in attractiveness.

One's attraction is seen by the other side and thus belongs to the "eye of the beholder". However, a firm can work on its attraction in order to improve (or decrease) its attraction potential. Attraction in business relationships has been described as the factor that creates voluntary commitment, which can mobilize buyer-supplier resources.

The concept of attractiveness in business relationships has also been discussed in several studies. Heide et al. presented 1992 their study about *norms in marketing relationships*. They showed that norms play a significant role in structuring economically efficient relationships between independent firms. In the absence of supportive norms, it is not possible for parties, whose specific assets are at risk, to acquire vertical control as per the transaction cost prescription. Instead, those parties lose control because of their dependence. Heide et al. included in their measurement statements about buyer control and buyer-specific assets, and statements concerning norm of flexibility, information exchange and solidarity. An empirical test of the conceptual model in a sample of manufacturer-supplier relationships showed good support for the author's hypothesis.

In 1997 Olsen et al. proposed *a portfolio model for managing supplier relationships* and developed a set of propositions for managing the supplier relationships. They used as a point of departure the models developed by Fiocca and Kraljic. Olsen et al. introduce a three-step approach to analyze the relationships where step 1 is to position the purchases in suggested model where key dimensions are the strategic importance of the purchase and the difficulty of managing the purchase situation. In step 2 the firm analyses the relationships with a model where dimensions are relative supplier attractiveness and the strength of the relationship between the buyer and the supplier. Step 3 concerns developing action plans where the authors give examples and guidelines based analysis in the previous steps.

Walter et al. proposed in 2003 *a concept of direct and indirect functions of supplier relationships and analyzed their impact on relationship quality*. They measured direct and indirect functions, relationship quality and availability of alternative suppliers with altogether 44 items. Direct and indirect functions of a supplier relationship were found to be significant predictors of customer perceived relationship quality, and further, both direct and indirect functions of supplier relationships have a stronger influence on relationship quality when the availability of alternative supplier is relatively high. The paper made an innovative contribution with regard to construct measurement and developed valid measurement scales.

In 2008 Hald et al. draw attention to ways of managing in a relational model as an alternative to managing in a controlling mode. The article is based on social exchange theory. The authors follow Blau (1964) and label the force that pushes a buyer and supplier closer together in a dyadic relationship "attraction". Blau defines attraction as "the force that induces human beings to establish social associations on their own initiative and to expand the scope of their associations once they have been formed". The authors propose *a conceptual model of attraction* and first ideas on how to influence attraction. In the conceptual model the attractiveness is divided into three areas: value, trust and dependence, which each are divided into components. These are seen as forces that either pull the partners together or push them apart. The components are defined as *perceptions* held by both the customer and the supplier. Attraction is constructed as the combined output of complex interaction between expected value, trust and dependence.

Table 1 below draws a summary and presents elements of attractiveness as discussed in the literature both by the above mentioned authors and a few additional authors. The attractiveness has been discussed in levels of individuals and organisations.

Table 1. Elements of attractiveness as discussed in the previous literature.

Hald and Vollman 2008	• Perceived expected value • Perceived trust • Perceived dependence
Fiocca (1982)	• Market factors • Competition • Financial and economical • Technological factors • Sociopolitical factors
Olsen and Ellram (1997)	• Financial and economical factors • Performance factors • Technological factors • Organizational and cultural factors • Strategic factors
Harris et al (2003)	• Economically based • Resource based • Socially based
Ellegaard 2002, Ellegaard et al 2003	• Economically based • Resource based • Socially based
Cordon and Vollmann (2005)	• Expected value • Comfort

RESEARCH APPROACH

The research was conducted as a multiple in-depth case study. The unit of analysis was a customer–supplier dyad. There were two focal case companies (customers), and in both case companies three dyads were studied (i.e. in total six dyads). Data collection was based on interviews with people representing all collaborating functions and different organizational levels of the two case companies and selected supplier companies. Altogether 42 interviews were carried out. The selection of suppliers was made by the customer companies' purchasing management. The aim was to select different types of suppliers. Each participating company selected the interviewees by itself.

The main research instrument for data collection was based on the model proposed by Hald et al. (2008), comprising three elements of attraction in a business relationship: perceived expected value, perceived trust and perceived dependency (figure 1). The focus of data collection was on these elements of attractiveness and on their role and importance in different supplier relationships.

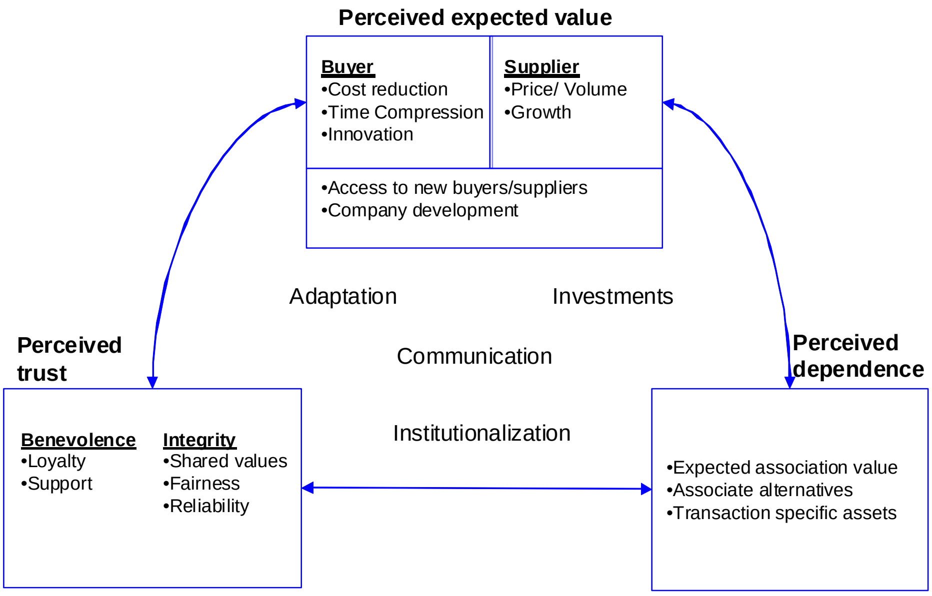

Figure 1. *A conceptual model of attraction in buyer-supplier relationship (Hald et al 2008)*

The three elements of attraction, value, trust and dependence were divided into several components based on research of Hald, and modified based on e.g. Walter (2003) and Olsen (1997) (Table 2). Under the components, several statements describing the relationship were created.

Components of *value* include according to Hald et al. cost reduction, innovation, access to new supply chain partners and competence development from the customer viewpoint. From the supplier viewpoint the components include price, growth, access to new partners and company development. We added to our interview chart statements concerning also time compression, R&D, information flow and quality.

Hald et al. see that in dyadic relationships, *trust* has a moderating influence on value perceptions of attraction. Trust is highly subjective and influenced by daily activities and thus changes rapidly. Hald sees ability, benevolence and integrity as the components of trust, of which ability is already included in the value perception. We added to our model also social support, customer commitment and solidarity as statements of trust.

Perceived *dependence*, according to Hald, has a moderating influence on perceived expected value. It can either weaken or strengthen the actor's overall perceptions of attraction. Relationship dependence has been defined as the degree to which a buyer or a supplier needs to maintain the relationship with a supplier or a buyer in order to achieve desired goals. We measure the perceived dependence with statements concerning transaction specific assets, human specific assets, associate alternatives and expected association value.

Table 2. Elements and their components of attraction in the study.

Perceived expected value	**Perceived trust**	**Perceived dependence**
• Price reduction	• Benevolence	• Transaction specific assets
• Operative cost	• Integrity	• (Human) specific assets

• Time Compression • Innovation • R&D • Information flow • Access to new SC partners • Company development • Quality	• Social support • Customer commitment • Solidarity (Heide et al.)	• Associate alternatives • Expected association value

The interviewees were asked to rate a) the state of each statement on scale 1 = strongly disagree, 5 = strongly agree, and b) the importance of each statement on scale 1 = no importance, 5 = very important. The customers were asked to rate the statements concerning the "attractiveness of the supplier". Respectively, the suppliers were asked to rate the statements concerning the "attractiveness of the customer". The interviewees were also encouraged to give comments concerning the statements. In addition, there were also open questions, e.g., what makes supplier/customer attractive, what kind of collaborative development has been done in the relationship and what should supplier/customer do to improve attractiveness.

The interviewees were also asked an opinion on five statements about control in the relationship on a scale 1 to 7 (1 = entirely decided by the supplier, 7 = entirely decided by the customer). The purpose of these statements was to have a view about who has the control concerning different matters in the relationship. Also, the interviewees were asked to prioritize the general development objectives of the relationship and rate the success of achieving the objectives.

Table 3. How perceptions of expected value, dependence and trust work in combination to produce perceived attraction (Hald et al, 2008).

Expected value	**Perceived dependence**	**Perceived trust**	**Resultant perceived attraction**	**Consequent action of associated actor**
High	High	High	High	High attraction, though concerns about dependence
High	Low	High	High	High attraction
High	Low	Low	Medium	Will be annoyed about the associates's behaviour and find working together frustrating
Low	High	High	Medium	Should feel a dangerous sense of coziness and convenience. Need to jointly develop the dyad expected value
Low	Low	High	Medium	Could feel a dangerous sense of coziness and convenience.
Low	High	Low	Low	Will seek to reduce dependence and leave the relationship. Probably not participate in joint development efforts.
Low	Low	Low	Low	Will seek to reduce dependence and leave the relationship.
High	High	Low	Low	Will seek to reduce dependence and leave the relationship.

FINDINGS

The descriptions and main results of the different cases are presented in tables 4 and 5. The results on questions "what makes supplier/customer attractive" are based on respective open questions in the questionnaire. The answers to these were consolidated to coherent groups and the top three groups are presented in the tables. The perceived expected value, trust and dependency present the averages of given ratings by both the customer and supplier interviewees. The evaluation of the resultant perceived attraction is based on the model presented by Hald et al (2008), see table 3.

Table 4. Description and results of customer-supplier dyads of case 1.

Dyad	A1		A2		A3	
No of interviews at customer	2		4		3	
No of interviews at supplier	3		5		1	
Interviewees' relationship duration with the supplier (years)	2-10		1-7		1-3	
Characteristic of customer	Finnish company, strong presence in Northern European market					
Characteristic of supplier	Finnish SME, printing service provider		European multinational (subsidiary), manufacturing service provider		Asian capable low cost supplier, R&D and manufacturing service provider	
Control of the relationship	Mostly customer		Strongly customer		50/50	
What makes supplier attractive	Long term relationship Competitive price & cost efficiency Good quality and delivery reliability		Co-operation, trust and personal relationships Competitive price and cost efficiency Know-how and experience of industry sector		Co-operation, trust and personal relationships Competitive price and cost efficiency Know-how and experience of industry sector	
What makes customer attractive	Long term relationship Volume and suitable size Financially stable		An innovation driver Good communication Volume and suitable size		Volume and suitable size	
Perceived expected value (c/s)	3,7	3,3	3,3	3,45	2,7	4,1
Perceived dependence (c/s)	3,5	3,7	3,4	3,15	3,4	2,1
Perceived trust (c/s)	4,2	4,15	3,7	4,0	2,8	4,9
Resultant perceived attraction (c/s)	high	high	high	high	low	high

Table 5. Description and results of customer-supplier dyads of case 2.

Dyad	B1		B2		B3	
No of interviews at customer	6		5		5	
No of interviews at supplier	2		3		3	
Interviewees' relationship duration with the supplier (years)	2-15		1-3		8	
Characteristic of customer	Multinational company with very global markets					
Characteristic of supplier	Multinational company with very global markets, R&D and manufacturing service provider		Multinational company with very global markets, Component provider		Multinational company with very global markets, manufacturing service provider	
Control of the relationship	Strongly supplier		Mostly supplier		Strongly customer	
What makes supplier attractive	Competitive prices Technology capability Commitment and long term relationship		Flexibility & co-operation Global operations Brand and reputation		Global operations Competences & their development	
What makes customer attractive	Willingness to develop collaboratively Large volumes and growth potential Relationships at all levels between organizations		Large volumes and growth potential Willingness to develop collaboratively Reliable		Large volumes and growth potential Relationships at all levels between organizations Financially stable	
Perceived expected value (c/s)	3,85	3,75	3,5	2,9	4,0	2,6
Perceived dependence (c/s)	3,35	4,3	3,35	3,5	3,0	1,6
Perceived trust (c/s)	4,2	4,25	3,9	3,6	4,3	3,6
Resultant perceived attraction (c/s)	high	high	high	medium	high	medium

The results show that most of the relationships were rated as highly attractive. Out of six dyads in one the customer rated attraction to "low" and in two dyads supplier rated attraction to "medium". One explaining factor for the generally positive result is that Hald's (2008) evaluation table is biased to the positive side by emphasising the trust element of attraction. Even if value and dependence elements are rated low, high trust rating elevates the resultant attraction to medium. In our case dyads all but one rated the trust element high. Trust was also the element in which there was least difference between customer and supplier viewpoints.

One dyad (A3) was rated low by the customer. In this case, Hald et al (2008) evaluation table suggest that company "Will seek to reduce dependence and leave the relationship. Probably not participate in joint development efforts". There was discussion going on in the company about what to do to enhance the relationship but leaving the relationship was not on the agenda. Instead, there was strong push for joint development. In that sense the actions in the company did not follow Hald's suggestion. It is also interesting that the supplier viewed the relationship in a very positive light. This dyad was between Finnish and Asian company, so possible influencing factor is different culture (or cultural distance) which may affect both to the way the status of the situation is seen and also how it is told to be (e.g., when answering to our research questions). It has to be noted that there was only one person interviewed at the dyad A3 supplier.

In the case B two suppliers rated the relationship to medium. Case B dyads are quite similar to each other, all being multinational-multinational relationships. Multinational companies usually have several customers, thus the value and dependence concerning a single relationship is not so significant. That lowers the rating to medium level.

One factor influencing to the lower ratings could be the length of the relationship. In dyads A3 and B2 the length of the relationship was 3 years maximum (at least concerning the persons interviewed). It can be argued that the longer the relationship the more attractive it can be perceived to be. Long relationship manifests that something is working well in the relationship. On the other hand, if the relationship is young there can be starting problems which affect to the perception of attractiveness.

The results produced by the study were presented to both customer companies. In the workshops the overall outcome of the study was considered to be well in line with the companies' view. One interesting point brought up in the workshops was the discrepancies in the ratings between personnel from different functions in the companies. The same relationship may appear quite different depending on function. Aggregating these different ratings to one single number is a challenge to our research method.

One of the companies decided to add elements of our research questionnaire to their annual supplier survey to get long term follow-up how the supplier relationships develop from the attractiveness point of view. Thus, in spite of shortcomings, something in the method proved usable to practitioners.

DISCUSSION

The concept of attraction provides means to bring the softer issues of supply relationships into the discussion. So far, research has provided mainly conceptual models. The challenge is to have methods and tools with which the softer elements can be evaluated and influenced in practice (Hald et al, 2008). In this paper we have described one approach based on previous research on attractiveness in business relationships. From practitioner point of view the overall result is encouraging on the ground that one of the case companies wanted to adapt parts of the method to its annual supplier survey. However, several challenges remain. One is the aggregation of differing perceptions by persons from different functions. In this study we used simple averages which may not reflect the overall situation of the company properly. Second is the control of cultural differences. Our study suggests that depending on the culture (company and/or population), getting the perceptions of all the relevant persons included may be difficult. This may influence significantly to the evaluation reliability. Thirdly, getting from attractiveness evaluation and rating results to the development actions requires deep analysis of all the elements and their sub-components together with broader knowledge of the relationship. Ratings themselves don't give answers what kind of actions to take.

REFERENCES

Blau, Peter M. (1964), Exchange and power in social life, New York: John Wiley & Sons

Cordon, C. and T.E. Vollmann (2005), Who is the fairest of them all?, CPO Agenda.

Ellegaard, C. (2002). The dynamics of managing supply at the dyadic relation and network level. 7th International Symposium on Logistics and the 2nd International Symposium on Operations Strategy in Melbourne, Australia, July.

Ellegaard, C., Johansen, J. and Drejer, A. (2003), Managing industrial buyer-supplier relations – the case of attractiveness, Integrated Manufacturing Systems, Vol. 14, No 4, pp. 346-357.

Fiocca, R. (1982), Account portfolio analysis for strategy development, Industrial Marketing Management, vol. 11, pp. 53-62.

Hald, K.S., Cordon, C. and Vollmann, T.E. (2008), Towards and understanding of attraction in buyer-supplier relationships, Industrial Marketing Management, 2008.

Harris, L.C., O'Malley, L. and Patterson, M. (2003), Professional interaction: Exploring the concept of attraction, Sage Publications, London.

Heide, J.B. & John, G. (1992) Do Norms Matter in Marketing Relationships?, Journal of Marketing, April, pp. 32-44.

Kettunen, O., Aminoff, A., Kortelainen, K., Tanskanen, K. (2009). Attractiveness in Buyer-Supplier Relationships: An Agenda for Empirical Research. POMS 20th Annual Conference Orlando, Florida U.S.A. May 1 to May 4, 2009.

Olsen, R. and Ellram, L. (1997), A Portfolio Approach to Supplier Relationships, Industrial Marketing Management, Vol. 26, No. 2, pp. 101-113.

Walter, A., Muller, T.A., Helfert, G., Ritter, T. (2003) Functions of industrial supplier relationships and their impact on relationship quality, Industrial Marketing Management, 32, pp. 159-169.

BUYER-SUPPLIER RELATIONSHIPS IN THE MALAYSIAN RETAILING INDUSTRY

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ABSTRACT
Maintaining an excellent relationship between buyer and seller is crucially important; a link of consideration to discover the crucial elements within industrial marketing. Thus, the purpose of this study is to explore relationships among business interactions in most marketing distribution channel that combined these principles, communication, trust, commitment, satisfaction and cooperation, into one framework. This research will entirely connected between communication formality and relationships qualities of Malaysian retailers and its key suppliers, unlike common studies found in automobile industry. This study will provide insight on antecedents and consequences of buyer-seller interactions specifically evolved around the relationship quality. This work considers retailers perspectives reporting on their major suppliers from quantitative survey method to generalize findings. This paper suggested a framework to be test by carefully choosing only product related retailers from a population of 2,794 total numbers of retailing companies listed by the Company Commission of Malaysia. A set of questionnaire will be distributed through mail to the purchasing manager. Structural Equation Modelling (SEM) will be adopted as to examine the proposed framework and hypothesizes.

Purpose:
The purpose of this study is to explore relationships among business interactions in marketing distribution channel that combined these principles namely, communication, trust, commitment, satisfaction and cooperation. This research will entirely connected between communication formality and relationships qualities of Malaysian retailers and its key suppliers. It addresses the effect of formal vs. informal communication towards trust, commitment and satisfaction as the relationship success factor which at the end resulted on cooperation as the ultimate outcomes. This study will demonstrate the important of relationships through analyzing antecedents, consequences, and inter-relationship of each constructs. To further focus on trust as the crucial relationships factor, variable of trust will be decomposed into five level as to investigate the cross sectional relationships. It end with the propose framework for the studies.

INTRODUCTION

In many industry, inter-firm relationships is crucially important as organization put a lot of effort to keep up with rapid changes that evolve around the business world. Thus, relationships have become a vital competitive instrument in every business area to ensure and maintain the overall business growth and development. Intense competitions from local and foreign players, forced company to rely on relationships characteristics as a significant strategic weapon in the global competitive environment. Therefore, an understanding of the organizational buying and selling relationships of inter firm is one of the development pillars for effective industrial marketing channel strategy as smaller amount of attention are given to industrial buying.

LITERATURE REVIEW

Background

Research concerning inter-firm relationship's related to marketing channel started in late sixties, mainly focuses on single exchange relationship and topic such as power and conflict during early stages. However, experts concern on industrial research, tend to exhibited pressure. Since 1980s with the new approaches particularly to satisfy ultimate customer through creativity and efficiency, confrontation strategies are replaced with cooperative dealings of partnership, boundless organizations, alliances and long term orientation to name a few or widely recognize as healthy relationship marketing. The aim is to optimize overall performance based on effective management of the entire network of supply that benefited every entities (Young and Wilkinson, 1989; Miles et al, 1990; Crotts and Turner, 1999; Parson, 2002; Chen, 2006;Nes, Solberg and Silkoset, 2007).

In such, research on channel relationships management between buyer and seller has increasingly focused on in depth studies on communication (see Klein et al, 1990; Mohr and Sohi, 1995; Geyskens, Steenkamp and Kumar, 1998; Selnes, 1998; Rodriguez, 2005; Shindav, 2005); which is acknowledge as the central to function channel and relationships effectively (Ambrose, 2008). Communication behaviour has linked to various roles including trust, channel structure, commitment, coordination and cooperation. Clearly, these behaviours are important factor to channel relationship development and relationship quality assessment. In relationship marketing theory, constructs of trust, commitment, satisfaction and commitment have been identified as the core concepts in understanding the dynamics of relationships evolvement; proven with vast literatures thoroughly examined on above mentioned. (See Barnes, 1994; Wren et al., 1996; Crotts and Turner, 1999; Garbarino & Johnson 1999; Mohr et al., 1999; Bennet and Gabriel, 2001; Bigne and Blesa, 2002; Jonsson and Zineldin, 2003; Rodriguez, 2005; Chen, 2006; Liu et al. 2007); Sahadev, 2008).

Little attention however is stressed on the importance of cooperation and commitment in marketing channel. Thus, this research is an attempt to include both constructs within the relationship quality framework to discover its connection with other outcomes. Additionally, the underlying reasons for cooperation in marketing channel also remained as a secret. Moreover, as much as literature stressed on the important of relationships constructs, it is vital to question on interrelationship between these constructs, which have not been addressed properly (Young and Wilkinson, 1989; Selnes, 1998; Rodriguez, 2005) In addition, this research will used constructive relationships of highest level academic support that is communication, trust, satisfaction, commitment and cooperation as a success functioning in between business relationships (Buhler, Heffernan and Hewson, 2007) with further decomposition of communication formality and level of trust; examined within one a single framework.

In addition, Most of the research in these areas focuses on a particular industry that is automobile industry with 75% conducted in US; showing a relatively lack of research on in non-western settings, emerging markets of Asia, Eastern Europe and Latin American. Majority of study also consisted in commercial channel member with the least picked from retailing sector (Geyskens, Steenkamp and Kumar, 1998; Lai et al, 2007). As distribution-marketing channels are designed with the needs of target market and business relationship, it is believe that countries it might vary, perhaps in length of channels and infrastructures. With the lacking in non-western marketing channels, this research indirectly be able to show an insight from Asian perspectives specifically from the retailing sector. It is important as Nes, Solberg and Silkoset (2007) stressed on cultural differences as the key factors to influence conception and understanding of variables and situation. Thus, there is a need on further analysis in other country as it has affected the premises of theoretical models used in channel relationships whether generalization could be made from current available models.

Retailing in Malaysia

Retailing comprises of business activities involved in selling goods and services to consumers for personal, family or household use. In other word, it includes every sale to the final consumers (Berman and Evans, 2004). However, the Department of Statistics Malaysia has a slightly different definition classified under retail trade (Euromonitor, 2004). Retailing includes establishment engaged in selling to the public, from displayed merchandise products such as typewriters, stationery, petrol or lumber, though they may not be personal or household consumptions. It also includes establishment primarily engage in renting of goods to the public for household or personal use. However, it does not cover rental of amusement and recreational goods such as boats and canoes, motorcycles, bicycles and saddle horses. In addition, retailing also comprises of repair and installation services rendered by establishments mainly engaged in the retail trade. Nevertheless it does not include bakeries, slaughterhouses, boutiques (if the mainly activity is tailoring and selling self-design clothing), tailoring and photo framing.

Retailing industry in Malaysia is expanding over the years. With economic growth and rapid development especially after the downturn recovery, higher disposable income, rising population, increasing purchasing power, consumer expenditure and government assistance through various fiscal, monetary policies and information technology utilization has driven towards greater retail sales. Additionally, relaxation of franchising regulations, growth in hyper shopping malls, local interest towards branded items and frequent events encourage to active consumer spending boosting up the retailing sector (Euromonitor, 2007). With that, the retailing industry emerge to be the second biggest contributor under manufacturing industry towards national Growth Domestic Product (GDP) Therefore, to stay in this competitive market, retailers have to strengthen mechanism of its marketing channels, adapting strategic management with its channel members to keep up with challenging business world.

Relationships Marketing between Channels Members

The relationship marketing terms became famous in 1990s where many researchers, practitioners and academician started to acknowledge the concept as an important constructs in business achievement. It is recognize as the 'new' marketing paradigm. Relationship marketing involves affiliation with customers, competitors, sellers and the whole entities within marketing channel by establishing, maintaining and enhancing relationship (Jap, Manolis and Weitz, 1999; Buhler, Heffernan and Jewson, 2007). The basic aim is to increase profits by attaining a rising proportion of specific buyer and seller interaction over lifetime rather than to maximize profits from short-term transactions where parties were more concern with the results of their specific transaction. Relationship marketing foster long-term and closer relationship between entities of marketing channel from customers and collaborate with interdependent to one another (Wann, 1998; Wren and Simpson, 1996). Buhler, Heffernan and Hewson (2007) conducted a meta-analysis in relationship marketing and manage to compile literature on the field. They found that relationship quality constructs have been studied in various researches from vast perspective with communication, trust, satisfaction, commitment and cooperation to be most frequent construct used.

Several researchers claimed an argument both in the topics of which out of the five constructs are the antecedents and consequences of a relationship success with their own judgment and support. Some indicates satisfaction as the antecedents of trust while some propose the opposites (Jonsson and Zineldin, 2003; Rodriguez; 2005; Shindav, 2005). Additionally, trust is regarded as antecedent to communication and vice versa. Others indicate trust to influence commitment and the other way round (Selnes, 1998; Crotts and Turner, 1999; Rodriguez, 2005; Lai, 2007). Nevertheless, the exchanges of information through communication, cooperation and commitment relationships enhance satisfaction and efficiency by coordinating effort of both in inter organizational relationship. Regardless, in the literature review, a successful channel relationship requires a great deal of above mention elements

Communication as Antecedents

However, past researchers claimed that the right combination of relationship arrangement with communication as the main key infrastructure paves the way for successful positive outcomes (Mohr, 1999). The most prevalent definition in communication is the way formal and informal information are given and received (Nes, Solberg, Silkoset, 2007). Therefore, this research will further decompose the elements of communication into informal and formal communication, similar to its definition as to validate the above description. It is choose as the antecedents of relationship quality as communication is regards to be central in relationship marketing (Selnes, 1998).

Research in the field of organizational studies claimed that organization accomplish communicatively built around a communicative process. In such, several relationship-marketing scholars agreed that communication is a fundamental aspect of relationship development

(Shindav, 2001; Rodriguez et al, 2006). Previous research had also stressed on the importance of communication as the basic for integrating activities within and between organizations (Dash et al., 2007). Communication coordinated behaviour in organization, glued inter-organizational channel of distribution entities. It plays a central role in providing an understanding of the exchange partners' intentions and capabilities that form the groundwork for relationship development. In marketing relationships, communication serves roles including informing, listening and answering, which require interaction and two-way communication (Duncan and Moriarty, 1998; Mohr et al., 1999).

Clearly, inter-organizational communication between marketing channels members is considered important elements in ensuring channel positive outcomes. Mohr et al. (1996) concludes collaborative communication within marketing channel are a combination of four aspect namely frequency (high or low), directionality (either bi-or-uni-directional), formality (formal or informal medium) and content of influence attempts (direct or indirect messages). The contribution of above all relates to associate with commitment, satisfaction and cooperation. Thus, communication guide and administer the relationship with the basis of mutual support and respects, focusing on shared interest and goals. For this paper, researcher focuses on communication formality dimension by decomposing communication constructs to formal (Fax, mail, EDI, E-Mail, numeric computer output and written bulletin/document) and informal (face-to-face, videoconference, telephone, instance messaging and written memos) medium. This research considers communication as the antecedent's key factor of a successful relationship. A significant communication between channel members enhances trust by increases the level of knowledge of partner's activities to predict the actions (Nes, Solberg and Silkoset, 2007).

Trust in Marketing Channel

Trust, as in most literatures is defined as the extent to which exchange partners perceive that the other party will perform as promised in the relationship with honesty and integrity/ benevolent. It eliminates the need for contract and limited extend of formal control (Liu et al., 2008). Trust derives from previous relations during time length of relationship development and shared goals, increase over time length of the relationship and dyadic solidarity (Liu et al. 2007). It is a key dimension in any business venture recognized to be naturally interpersonal and inter-firm issues based on the overall relationship rather than on particular episodes of behaviour (Young and Wilkinson, 1989; Geysken et al., 1998. Buhler, Heffernan and Hewson, 2007; Nes, Solberg and Silkoset; 2007;). A higher level of trust enable both parties to pay more attention on aims of the interaction rather than controlling each other to avoid any advantages taken.

In most studies, researcher decompose elements of trust into two dimensions namely honesty and benevolence /credibility (Young and Wilkinson, 1989; Geyskens, Steenkamp and Kumar, 1998; Liu et al., 2008). Other modes of trust were differentiate by Zucker (1986) categorizing it into three which is the process-based trust emerging from recurrent transactions or relations. Secondly, characteristics-based trust that rest on social similarity and thirdly institutions trust based on its surrounding transactions such as contract. Liu et al. (2007) on the other hand separate the elements of trust into competence and goodwill. Therefore, trust instruments in a variety of setting have been applied to validated trust in marketing channel relationships. However, this work has much focused on trust as a whole, instead of analyzing the effect of different construct of trust. Therefore, this research will fill such gaps by decomposing the construct of trust into five levels as suggested by Crotts and Turner (1999). The five level of trust are reciprocal trust that refers to participants processing mutual between each other. Secondly, an earned trust is based upon some experiential basis. Verifiable trust refers to stability of one firm to verify the actions of another. Calculative trust is based upon costs or benefits of cheating or staying in a relationship while blind trust is base on lack of knowledge or irrational basis.

Satisfaction in Marketing Channel

Researchers define satisfaction in many terms but most derive from Anderson and Narus (1984) pioneered research. Consensus in this area arrived that in any terms relationship satisfaction is regarded as an affective or emotional state towards evaluation of all aspects of the relationship as a whole. Satisfaction is an emotional reaction to the divergence between what is predicted and what is accepted, based on experiences evaluation within the relationship. It derived from products, services, financial, welfare and emotion aspects (Jonsson and Zineldin, 2003, Ping Jr., 2003). To further classified satisfaction, Geyskens, Steenkamp and Kumar (1998) identified two dimensions of satisfaction in channel relationship namely economic satisfaction and non-economic satisfaction. However, it is claimed that economic satisfaction has a positive effect towards non-economic. The relationship of primary outcomes is economic satisfaction, whereby members has survived and nurture. By fulfilling the need of economic satisfaction effectively, it is assumed that it enhanced social and economic satisfaction (Geyskens, Steenkamp and Kumar, 1998; Rodriguez, Agudo and Gutierrez, 2006). Therefore, this research considers satisfaction as a single constructs.

Commitment in Marketing Channel

Commitment refers to enduring desire to maintain a valued relationship. It is central to all relational exchange between channel members to achieve valuable outcomes and to ensure survival of long-term relationships. Commitment required channel members to trust each other and belief relationship continuity are essential as to take any effort to maintain such relationship and motivates them to ignore short-term inadequacies and to look up at long-term possibilities (Crotts and Turner, 1999; Ping Jr., 2003; Buhler, Heffernan and Hewson, 2007; Sahadev, 2008).

Cooperation in Marketing Channel

Studies on the area of cooperation individually in channels started to emerge in late seventies. An element provides agreement to both parties to continue trading with understanding of business nature. Taken from Anderson and Narus (1990) definition of cooperation is a complimentary actions taken by firm in interdependent relationships to achieve mutual outcomes with expected reciprocation over time. It is a proactive action of giving and taking, that partners take in creating direction of relationship with the willingness to be flexible for partner's interest (Morgan and Hunt, 1994; Brock and Smith, 1997 in Buhler, Heffernan and Hewson, 2007). Trust, commitment and satisfaction are the two mediating variables that promote marketers to preserve relationships investment with the means of cooperating with partners which at the end resulted in relationship stability (Liu et al., 2007). However, cooperation is the less construct included in marketing relationships channel outcomes research although the importance of this constructs has been acknowledge as the 5 crucial means of measuring relationship marketing (Buhler, Heffernan and Hewson, 2007). Therefore, this research framework will filled the gap by including the constructs into the framework.

Conceptual Framework

The proposed framework is base on gaps from previous research area. The following model shows variables of antecedents and consequences of relationship qualities in marketing channel. This model identifies key factor known to influence trust, which is communication and interrelations with outcomes of relationship marketing. Furthermore, communication is regarded as the precursor of trust with commitment, satisfaction and cooperation to be the consequences or outcomes of the relationship.

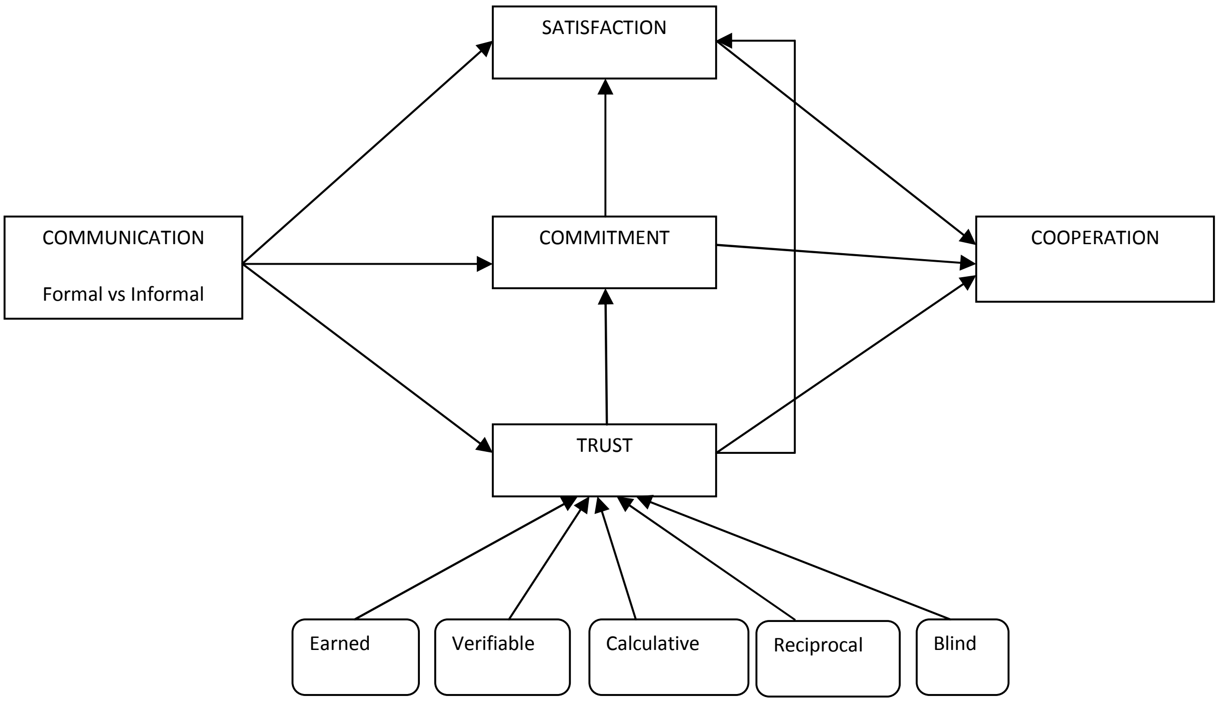

Figure 1: Conceptual Framework

Methodology

The proposed framework will be tested by carefully choosing only product related retailers from a population of 2,794 total numbers of retailing companies listed by the Company Commission of Malaysia. Product related companies are choose as it involves large establish organization with several suppliers interactions. A set of questionnaire will be distributed through mail to the purchasing manager; evaluating the relationship with major supplier. Structural Equation Modelling (SEM) will be adopted as to examine the proposed framework and hypothesizes. Specifically it will measure the strength and connection of communication, trust, commitment, satisfaction and cooperation. Additionally, the level of trust and the communication formality in retailing industries is another concerned of this study. Review from previous studies will lead to developing of questionnaires for new construct namely the five levels of trust (earned, verifiable, calculative, reciprocal and blind) as well as the formal vs informal communication. Meanwhile, adaptation of instruments from previous marketing relationship field will be applied for available constructs. The constructs of trust, commitment and cooperation will be evaluated through measurement item by Morgan and Hunt, 1994 while satisfaction will be measured through questionnaire constructs of Frazier et al., 1989 and Andaleeb, 1996.

Conclusion

This study proposed a framework to analyze the antecedents and consequences of buyer-seller interactions specifically evolved around critical variable for the success of a relationship marketing. The research is anticipated to discover specific behaviours that effect buyer-seller relationship, by which should retailers taken into account on any interactions. It will also inform practitioners of the process on how industrial buyer-seller relationship involved especially within the Malaysian perspectives.

REFERENCES

Ambrose E., Marshall D., Fynes B and Pynch D. (2008) "Communication Media Selection in Buyer-Supplier Relationships", in International Journal of Operation and Production Management.

Bennett R and Gabriel H. (2001) "Reputation, Trust and Supplier Commitment: The Case of Shipping Company / Seaport Relations", in Journal of Business and Industrial Marketing.

Berman B. and Evans J. R. (2004) "Retail Management: A Strategic Approach". Ninth ed. Prentice Hall.

Bigne E. and Blesa A. (2003) "Market Orientation, Trust and Satisfaction in Dyadic Relationships: A Manufacturer-Retailer Analysis", in International Journal of Retail and Distribution Management.

Blenkhorn D.L. and MacKenzie H.F. (1996) "Interdependence in Relationship Marketing" in Asia Australia Marketing Journal.

Buhler A.W.,Heffernan T.W. and Hewson P.J. (2007) "The Soccer Club-Sponsor Relationship: Identifying the Critical Variables for Success", in International Journal of Sports Marketing and Sponsorship.

Chen Z. (2006) "Chinese Retail Buyer-Seller Initiation and Maintenance of Relationships", Dissertation Doctor of Philosophy, Michigan State University.

Crotts J.C. and Turner G. B. (1999) "Determinants of Intra-Firm Trust in Buyer-Seller Relationships in the International Travel Trade", in International Journal of Contemporary Hospitality Management.
Dash S., Bruning E. and Guin K. K. (2007) "Antecedents of Long Term Buyer-Seller Relationships : A Cross Cultural Integration", in Academy of Marketing Science Review. Available : http://www.amsreview.org/articles/dash11-2007.pdf.

Euromonitor International. (2007) "Retailing in Malaysia", in GMID Report. Available: www.euromonitor.com/gmid.

Frazier G. L. (1999) "Organizing and Managing Channel of Distribution", in Journal of the Academy of Marketing Science.

Geyskens I., Steenkamp J. B. E. M. and Kumar Nirmalya. (1998) "Generalization about Trust in Marketing Channel Relationships using Meta-Analysis" in International Journal of Research in Marketing.

Garbarino E. and Johnson S. (1999) "The Different Roles of Satisfaction, Trust and Commitment in Customer Relationship" in Journal of Marketing.

Jap S.D., Manolis C. and Weitz B. A. (1999) "Relationship Quality and Buyer-Seller Interactions in Channels of Distribution", in Journal of Business Research.

Johnson P. and Zineldin M. (2003) "Achieving High Satisfaction in Supplier-Dealer Working Relationships", in Supply Chain Management: An International Journal.

Klein M. (1990) "A Management of Communication Strategy for Change", in Journal of Organizational Change Management.

Lai K. H., Bao Y. and Li X. (2007) "Channel Relationship and Business Uncertainty : Evidence from the Hong Kong Market", in Industrial Marketing Management.

Liu Y., Li Y., Tao L. and Wang Y. (2007) "Relationship Stability, Trust and Relational Risk in Marketing Channels: Evidence from China", in Industrial Marketing Management.

Miles M. P., Arnold D. R. and Wash H. W. (1990) "Adaptative Communication: The Adaptation of the Seller's Interpersonal Style to the State of the Dyad's Relationship and the Buyer's Communication Style", in The Journal of Personal Selling and Sales Management.

Mohr J. J., Fisher R.J. and Nevin, J. R. (1996) "Collaborative Communication in Inter-firm Relationships: Moderating Effects of Integration and Control" in Journal of Marketing.

Mohr, J. J. and Sohi, R.S.(1995) "Communication Flows in Distribution Channels : Impact on Assessments of Communication Quality and Satisfaction", in Journal of Retailing.

Nes E. B., Solberg C. A. and Silkoset R. (2007) "The Impact of National Culture and Communication on Exporter-Distributor Relations and On Export Performance. International Business Review".

Parsons A.L.(2002) "What Determines Buyer-Seller Relationship Quality? An Investigation from the Buyer's Perspective", in The Journal of Supply Chain Management: A Global Review of Purchasing and Supply.

Ping Jr, RA (2003)"Antecedents of Satisfaction in Marketing Channel", in Journal of Retailing.

Rodriguez I. D. B. R., Agudo, J. C. and Gutierrez S. M. (2006) "Determinants of Economic and Social Satisfaction in Manufacturer – Distributor Relationships", in Industrial Marketing Management.

Selnes F. (1998) "Antecedents and Consequences of Trust and Satisfaction in Buyer-Seller Relationships", in European Journal of Marketing.

Shindav B. (2001) "A Proactive Model of Communication in Marketing Channels", in Dissertation Doctor of Philosophy, University of Oklahoma.

Sahadev S. (2008) "Economic Satisfaction and Relationship Commitment in Channels: The Moderating Role of Environmental Uncertainty, Collaborative Communication and Coordination Strategy", in European Journal of Marketing.

Young L.C. and Wilkinson I. F. (1989) "The Role of Trust and Co-operation in Marketing Channels: A Preliminary Study", in European Journal of Marketing.

Wann C. W. (1998) "Eight Steps to Building a Business-to-Business Relationship", in Journal of Business and Industrial Marketing.

Wren B. M., and Simpson J. T. (1996) "A Dyadic Model of Relationships in Organizational Buying: A Synthesis of Research Results", in Journal of Business and Industrial Marketing.

CUSTOMER RELATIONSHIP MANAGEMENT: THE EFFECT OF CUSTOMER, SUPPLIER AND EMPLOYEE RELATIONS ON ENGINEERING PROJECT PERFORMANCE IN A MALAYSIAN SEMICONDUCTOR MANUFACTURING FIRM

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ABSTRACT

For many years, one recurrent theme within the literature on total quality management (TQM) is the study of its effect on organizational performance. However, most research has focused on analyzing the relationships between the implementation of different elements and several types of performance. There has been relatively little research on the role and effects of customer, supplier and employee relations on engineering project performance among Malaysian manufacturing industries. Hence, the objective of this study is to analyze customer, supplier and employee relations in a semiconductor manufacturing firm in Melaka and to determine its roles and influences on engineering project performance. The statistical analyses conducted indicate that strategic leadership and product/process management have a significant positive correlation with engineering project performance.

INTRODUCTION

Today, various firms disregard investments in assessing project management performance and are merely accentuating on meeting the time, cost and requirement of projects (Qureshi, Warraich, & Hijazi, 2009). Engineers often look upon projects as an achievement because of the excellent connection among stakeholders, albeit if every budget, schedule and technical performance were hardly anywhere above par (Wang & Huang, 2006). In successful organizations, actions and functions are designed with the aim of meeting the needs of customers so as to ensure long-term success as customer satisfaction relates to their retention and securing a more favourable market share (Fuentes-Fuentes, Montes, & Fernández, 2006). To gain competitive advantage in dynamic and turbulent business environments, it is important to emphasize quality when developing relationships with suppliers to collaborate on key supply chain processes effectively (Kaynak & Hartley, 2008).

However, Taylor (1998) explains that unless the customer-supplier-employee relationship parameters are measured, monitored and managed, the close contact with a customer can lead to a false sense of security and the loss of business, perhaps irretrievably. This shows that there is a need for quantitative studies in monitoring and measuring close customer/supplier and employee relations in projects. Little or no research has ever been carried out on the systemic affects of customer/supplier and employee relations on engineering project performance in Malaysian manufacturing firms.

As such this study aims to obtain empirical results on the effects of customer-supplier-employee relations towards engineering project performance by surveying engineering project leaders who are the nexus between management and workers that has not received adequate coverage in the engineering management and supply chain management literature. Hence, the research question identified for this study is:

> ‘***What is the extent to which customer/supplier and employee relations in a semiconductor manufacturing firm affect the success of engineering project performance?***

In this empirical study, the elements of customer/supplier and employee relations shall be analysed and correlated with engineering project performance.

LITERATURE REVIEW

Leadership

Project leadership refers to an existence and process executed within a managerial function that undertakes accountability for the requirements and privileges of employees who decide to abide the leader in completing the project (Cleland, 1995). Wang, Chou and Jiang (2005) believe that leadership's criticality in all team environments is high and it is essential for project managers to possess the qualities and skills required toward ensuring achievement, for instance abilities in managing employees, pressure, feelings, officialdom as well as interactions.

Shea and Howell (1999) speculate that by ascribing a mission and ideological goals which intensifies employees' awareness on the connotation and magnitude of their tasks, charismatic leaders may build a sturdy affective correlation connecting the employees and their work and promote their impetus to perform. Jung and Wang (2006) indicate that leaders who are obligated towards TQM by means of visualizing as well as strategizing, organizational TQM traditions along with purposes in technical performances, can ease continuous improvement of project management. Chin et al. (2002) pinpoint that top managing ranks should organize TQM initiatives as well as entrust goals in customer focus where managers must be authentically dedicated with more vigorous involvement.

According to Fuentes-Fuentes et al. (2006), higher management should direct the whole quality process at generating standards, positioning targets and improving systems deliberated to grant customer needs and perk up organizational performance. Kaynak (2003) concede that management leadership is imperative to build tactical alliances through contractors as well as to manufacture consumer focused goods.

However, severe dedications from higher managing levels in TQM that prove to be poor otherwise absent and complaints about management's lacking in patronage, refusal in amendment along with unsuccessful changes in organizational structures during TQM implementation often become common among employees (Kaynak, 2003). The aforementioned predicaments cause difficulties in cultivating TQM's potential benefits.

Product/Process management

Jung & Wang (2006, p. 721) suggest that product plus process managing are together by existing as technological characteristics in quality management. Ahire and Dreyfus (2000) suggest that workers joining sophisticated inventive managerial undertakings tend to implement TQM rudiments. They conclude that the employees' familiarity, know-how as well as characters concerning joint effort, collaboration as well as consumer emphasis ought to overflow towards continuing endeavors in following along with enhancing TQM in industrial practices.

Product and process management symbolizes managing application sequences, which allocate in favor of operational performances in different factors along with constituting technical approaches for analysis and investigations (Fuentes-Fuentes et al., 2006). Prajogo and Sohal (2006) consider technical performance to merely indirectly affect NPD performances via innovations in processes, whereby the tactic for practising product innovation or expanding product diversity can lead to embracing of process innovation due to the distinctiveness of the products that are coupled with certain production process characteristics.

In TQM projects, products and processes will advance the design away from exceedingly shallow emphasis on industrial characteristics toward usability engineering (Ebert & Man, 2008). Perdomo-Ortiz et al. (2006) posit that designing products searches for technical performance through obeying customer specifications. However, even as quality management supports magnitudes in innovativeness, approaches are responsive compared to enthusiastic, making quality management supporting NPD merely if unequivocal demands exist (Prajogo & Sohal, 2001).

Customer/supplier relations

In taking up the philosophy of TQM, measures and tasks were considered plus executed for satisfying customer requirements so as to guarantee accomplishment in a long run, for client approval connects with client care as well as business profits (Fuentes-Fuentes et al., 2006). Jung and Wang (2006) suggest that managing relationships with consumers is all about satisfying or surpassing their anticipations. Jung and Wang (2006) point out that distributing consumer-relevant knowledge within firms enables effectual customer relations administration. Kaynak and Hartley (2008) accede to the importance on highlighting technical performance while choosing contractors in handling procedures efficiently to avoid defects in received resources, meaning buyers can keep lesser emergency supplies meant for contingencies.

Abrunhosa and Sa (2008) bestow that being a customer-oriented philosophy, TQM strongly requires satisfying the customer expectations and this involves recognizing internal and exterior consumers considered. Forza and Filippini (1998) stress that in TQM, it is important to maintain very close associations with customers to identify their needs and to acquire the comments necessary so that a firm can evaluate the extent of success in fulfilling those requirements and thus instigate pertinent enhancement actions.

However, if an environment is barely aggressive and displays few impossibilities for the firm's growth, TQM firms react by consigning less prominence on customer focus actions (Fuentes-Fuentes, Albacete-Saez, & Llorens-Montes, 2004). Jung and Wang (2006) found that customer/supplier relations does not play the leading role in contributing for the success of continuous improvement in project management. Taylor (1998) concurs that through secure dealer-consumer affiliations better prospects on consumer needs exist. However, he exclaims that if the abovementioned factors remain unmeasured, unmonitored as well as unmanaged, this secure connection may create fake senses in guarantee along with loss in a business, perhaps irretrievably.

Johnsen and Ford (2007) argues that business marketing managers are possibly not capable in controlling NPD project supervision since commanding consumers interfere within the supplier choices as well as communications, although these consumers possess a smaller amount of technical familiarity. Their study shows there is a limit to which customer/supplier relations can benefit projects due to external interventions.

In summary, the foregoing problems seen on the influence of customer/supplier relations in projects are the lack of understanding in the extent of its emphasis, the lack of attention in measuring and monitoring its parameters and the lack of control in its choice and communication (Fuentes-Fuentes et al., 2004; Johnsen & Ford, 2007; Jung & Wang, 2006; Taylor, 1998). Therefore, with the aim of providing a better understanding in response to these gaps, the following hypothesis is proposed:

H1: Customer/supplier relations correlate with engineering project performance in a semiconductor manufacturing firm.

Employee relations

The challenge of TQM is to instill an consciousness of the significance of quality in all workforce and to motivate them to improve it (Krajewski, Ritzman, & Malhotra, 2007). Abrunhosa and Sa (2008) surmise that quality management emphasizes significances in connecting everybody within processes for consumer motivated continual enhancement, that may occur when every employee can be provided freedom with accountability in innovating as well as making judgments. Chang (2009) suggests that the exertion of enthusiasm and creativity of all the employees is the precondition of the actual effect of TQM.

As TQM transcends managerial borders, weights in workforce administration concerns like workshops as well as authority are expected for improvement (Kaynak & Hartley, 2008). Jung and Wang (2006) perceive that investments in employee relation's elements such as workshops in addition to seminars, proficient communicative instruments, occupation adjustability as well as security along with worker contentment prove to be major causal essentials in accomplishing continuous improvement within project management. The effectiveness of the firms that implement TQM depends on their knack to assure their workers that they wish to realize advantages from employee involvement (Kaynak, 2003). Fuentes-Fuentes et al. (2004) posit that reasons like the bond between colleagues or with their direct superior are influential towards organizational performance.

However, Kaynak and Hartley (2008) dispute that managers should identify with the fact that employee training may not necessarily impact customer focus directly although improved employee relations affects this relationship. Taylor and Wright (2003) argue that although extensive worker participation may be connected through project achievement, elevated degrees in worker participation cannot be adequate conditions in favor of effectual quality management implementation due to lack of measurement in the levels of employee involvement.

In short, employee training and employee relations may or may not be the binding factor that impacts customer focus in projects and lack of measurement in employee involvement levels provides vague proof to how far are the contributions of employee relations towards project performance (Kaynak & Hartley, 2008; Taylor & Wright, 2003). Hence, the following hypothesis is proposed:

H2: Employee relations correlate with engineering project performance in a semiconductor manufacturing firm.

RESEARCH METHOD

Quantitative research reflects the philosophy that everything in the social world can be described according to some kind of numerical system (McQueen & Knussen, 2002). For quantitative research, it is usually obvious what evidence is required and this evidence may usually be collected within a tight structure, whereby evidence collection often involves the use of a survey (Remenyi, Williams, Money, & Swartz, 1998).

A survey-based research might also be described as quantitative research, since the intention is to collect data that can be analysed so as to give a numerical description of the sample's voting intentions (Arksey & Knight, 1999). Surveys are positivistic methods that draw a cluster of themes from a population and are analysed to create conjectures on the population (Hussey & Hussey, 1997).

This study employed the use of a self-administered survey distributed to project leaders of engineering projects that have been completed in the past 18 months. Based on figures provided from the studied firm on projects from the last 2 years (since 2009), the firm had 3000 projects in total. Due to high turnover rate, transfers and resignation of project leaders, some projects are discontinued the population size for the study has been identified as 2100 projects.

As such, the unit of analysis employed would be the individual projects completed in this semiconductor manufacturing firm in Melaka. A total of 2100 surveys were handed out to the respondents of the firm according to workable projects. After a 1-month long data collection period, a total of 251 surveys were collected. 25 surveys had to be discarded from further data analysis due to issues of non-completion and legibility. The data were entered in SPSS 18.0 and analysed using factor analyses, correlation analyses and reliability analyses. The findings of the study are presented in the next section.

FINDINGS

Factor and reliability analyses

As detailed in Table 1, all the items presented recorded factor loadings that are well above 0.500. The items Lead_6, Emp_2, Emp_3, Emp_4, CustSup_1, CustSup_3, CustSup_4, CustSup_5, CustSup_6, ProdProc_7, ProdProc_8 and ProdProc_9 were dropped for data reduction purposes due to their low factor loadings. The highest ranked item in terms of factor loading is Lead_9 with a factor of 0.843 whereas the lowest is CustSup_2 with a factor of 0.500. The reliability test shows that the overall Cronbach's alpha for TQM is 0.953 which is adequately above 0.700.

While extracting and grouping the sub-variable items into components, it was discovered that several items from different sub-variables merged to form new sub-variables. Items such as Lead_1, Lead_2, Lead_3, Lead_4, Lead_5 and Emp_1 were merged to form the variable of strategic leadership. As for the variable which is product/process management, the items of ProdProc_1, ProdProc_2, ProdProc_3 and ProdProc_4 were grouped together with an item from the variable of customer/supplier focus and relations, which is CustSup_2. Since the item CustSup_2 involves the process of disseminating customer/supplier related information throughout the firm, therefore, the newly grouped variable name is retained as product/process management.

Thus, due to the development of newly integrated sub-variables, the hypotheses proposed for TQM in engineering project performance is restructured as follows:

Hypothesis 1: Strategic leadership correlates with engineering project performance in a semiconductor manufacturing firm.

Hypothesis 2: Product/Process management correlates with engineering project performance in a semiconductor manufacturing firm.

The reliability test shows that the Cronbach's alpha for each new variable is adequately above 0.700 at 0.921 and 0.873 respectively.

Table 1 Factor analysis for TQM

Factor	**Kaiser-Meyer-Olkin Measure of Sampling Adequacy**	**Bartlett's Test of Sphericity** χ^2	df	Sig.	**Cronbach's alpha**
TQM	0.923	3638.281	231	0.000	0.953

Item	**Factor Loading** **1** **Strategic leadership** **α = 0.921**	**Factor Loading** **2** **Product/Process management** **α = 0.873**
Lead_1	0.817	
Lead_2	0.832	
Lead_3	0.746	
Lead_4	0.726	
Lead_5	0.665	
Emp_1	0.536	
ProdProc_1		0.651
ProdProc_2		0.777
ProdProc_3		0.800
ProdProc_4		0.720
CustSup_2		0.500

(Source: developed for this study)

Pearson's correlation analysis

Pearson's correlation analysis is used to evaluate Hypotheses 1 and 2. A positive correlation result indicates a positive relationship between variables while a negative correlation value indicates a negative relationship between the two variables (Sekaran, 2003). The results of the correlation analysis are explained in the following sections. Table 2 presents the results of the correlation analysis to evaluate ***'Hypothesis 1: Strategic leadership correlates with engineering project performance in a semiconductor manufacturing firm.'*** The Pearson's correlation between strategic leadership and engineering project performance is 0.578 and the p value is 0.000. Therefore, the relationship between strategic leadership and engineering project performance is positive and significant. Therefore, hypothesis H1 is not rejected.

Table 2 Strategic leadership – Engineering project performance correlation

Test	Output	Interpretation
Pearson's Correlation	0.578***	Positive Correlation
Sig. (2-tailed)	0.000	Significant

* significant at < 0.05 level, ** significant at < 0.01 level, *** significant at < 0.001 level
(Source: developed for this study)

Table 3 portrays the results of the correlation analysis to evaluate ***'Hypothesis 2: Product/Process management correlates with engineering project performance in a semiconductor manufacturing firm.'*** The Pearson's correlation between product/process management and engineering project performance is 0.608 and the p value is 0.000. Therefore, the relationship between product/process management and engineering project performance is positive and significant. Therefore, hypothesis H2 is not rejected.

Table 3 Product/Process management – Engineering project performance correlation

Test	Output	Interpretation
Pearson's Correlation	0.608***	Positive Correlation
Sig. (2-tailed)	0.000	Significant

* significant at < 0.05 level, ** significant at < 0.01 level, *** significant at < 0.001 level
(Source: developed for this study)

DISCUSSION & CONCLUSIONS

According to earlier discussion regarding customer, supplier and employee relations in the literature review, the findings suggest that all of them do play role in the semiconductor manufacturing firm in order to improve the engineering project performance. The results were significant and positive for the hypotheses involving strategic leadership (r= 0.578, p=0.000) and product/process management (r=0.608, p=0.000) which contained the items from customer/supplier and employee relations. However, from the factor analyses conducted, it is found that the survey item factors for customer/supplier relations were merged with a significant amount of items under product/process management. This occurrence provides evidence that although customer/supplier relations is an important factor in enhancing performance, it may not be the key contributing element for that matter. This evidence is consistent with the study of Jung and Wang (2006) who found that customer/supplier relations does not play the leading role in contributing for the success of continuous improvement in project management.

Perhaps this finding is due to the environment context of the semiconductor manufacturing firm that possibly instigates certain policies or strategies that focus more towards other areas in TQM implementations, such as leadership or product/process management. This aligns itself with the theory from Fuentes-Fuentes, Albacete-Saez and Llorens-Montes (2004) who state that if an environment is barely aggressive and displays few impossibilities for the firm's growth, TQM firms react by consigning less prominence on customer focus actions. As for employee relations, it was found that a significant amount of items were merged under the leadership items in order to form strategic leadership. This is relevant according to the literature because employee empowerment, decision making and training requires direction and strategy from higher management beforehand so as to align with the firm's business strategies. This finding is consistent with the findings of Kaynak and Hartley (2008) who dispute that managers should identify with the fact that employee training may not necessarily impact customer focus directly although improved employee relations affects this relationship.

In addition to that, it was found that the influence of employee relations on improved engineering project performance is also enhanced with a positive relationship among direct supervisors and employees. This finding relates to the study of Fuentes-Fuentes et al. (2004) who posit that reasons like the bond between colleagues or with their direct superior are influential towards organizational performance.

These findings were consistent with the views obtained in the literature, as such '***Hypothesis 1: Strategic leadership correlates with engineering project performance in a semiconductor manufacturing firm'*** and '***Hypothesis 2: Product/Process management correlates with engineering project performance in a semiconductor manufacturing firm'*** are therefore not rejected. It was found that customer/supplier relations affect the success of engineering project performance to the extent where management leadership is concerned, whereby according to Fuentes-Fuentes et al. (2006), higher management should direct the whole quality process at generating standards, positioning targets and improving systems deliberated to grant customer needs and perk up organizational performance. Kaynak (2003) also concedes that management leadership is imperative to build tactical alliances through contractors as well as to manufacture consumer focused goods.

Employee relations also plays a role in the success of engineering project performance and is coupled with the undertakings of product/process management, as how Ahire and Dreyfus (2000) concur that workers participating in sophisticated inventive managerial undertakings tend to implement TQM rudiments. They conclude that the employees' familiarity, know-how as well as characters concerning joint effort, collaboration as well as consumer emphasis ought to overflow towards continuing endeavors in following along with enhancing TQM in industrial practices.

REFERENCES

Abrunhosa, A., & Sa, P. M. E. (2008). Are TQM principles supporting innovation in the Portuguese footwear industry? *Technovation, 28*(4), 208-221.

Ahire, S. L., & Dreyfus, P. (2000). The impact of design management and process management on quality: an empirical investigation. *Journal of Operations Management, 18*(5), 549-575.

Arksey, H., & Knight, P. (1999). *Interviewing for Social Scientists*. London: Sage Publications Ltd.

Chang, G. (2009). Total Quality Management in Supply Chain. *International Business Research, 2*(2), 82-85.

Chin, K. S., Tummala, V. M. R., & Chan, K. M. (2002). Quality management practices based on seven core elements in Hong Kong manufacturing industries. *Technovation, 22*(4), 213-230.

Cleland, D. I. (1995). Leadership and the project management body of knowledge. *International Journal of Project Management, 13*(2), 83-88.

Ebert, C., & Man, J. D. (2008). Effectively utilizing project, product and process knowledge. *Information and Software Technology, 50*(6), 579-594.

Forza, C., & Filippini, R. (1998). TQM impact on quality conformance and customer satisfaction: A causal model. *International Journal of Production Economics, 55*(1), 1-20.

Fuentes-Fuentes, M. M., Albacete-Saez, C. A., & Llorens-Montes, F. J. (2004). The impact of environmental characteristics on TQM principles and organizational performance. *The International Journal of Management Science, 32*(6), 425-442.

Fuentes-Fuentes, M. M., Montes, F. J. L., & Fernández, L. M. (2006). Total Quality Management, Strategic Orientation and Organizational Performance: the Case of Spanish Companies. *Total Quality Management & Business Excellence, 17*(3), 303-323.

Hussey, J., & Hussey, R. (1997). *Business Research: A Practical Guide For Undergraduate and Postgraduate Students*. London: MacMillan Press Ltd.

Johnsen, T. E., & Ford, D. (2007). Customer approaches to product development with suppliers. *Industrial Marketing Management, 36*(3), 300-308.

Jung, J. Y., & Wang, Y. J. (2006). Relationship between total quality management (TQM) and continuous improvement of international project management (CIIPM). *Technovation, 26*(5-6), 716–722.

Kaynak, H. (2003). The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management, 21*(4), 405-435.

Kaynak, H., & Hartley, J. L. (2008). A replication and extension of quality management into the supply chain. *Journal of Operations Management, 26*(4), 468-489.

Krajewski, L. J., Ritzman, L. P., & Malhotra, M. K. (2007). *Operations Management: Processes and Value Chains* (8th ed.). New Jersey: Pearson Education Inc.

McQueen, R., & Knussen, C. (2002). *Research Methods for Social Science: A Practical Introduction*. Edinburgh Gate: Pearson Education Ltd.

Perdomo-Ortiz, J., Gonzalez-Benito, J., & Galende, J. (2006). Total quality management as a forerunner of business innovation capability. *Technovation, 26*, 1170-1185.

Prajogo, D. I., & Sohal, A. S. (2001). TQM and innovation: a literature review and research framework. *Technovation, 21*(9), 539-558.

Prajogo, D. I., & Sohal, A. S. (2006). The integration of TQM and technology/R&D management in determining quality and innovation performance. *The International Journal of Management Science, 34*(3), 296-312.

Qureshi, T. M., Warraich, A. S., & Hijazi, S. T. (2009). Significance of project management performance assessment (PMPA) model. *International Journal of Project Management, 27*(4), 378–388.

Remenyi, D., Williams, B., Money, A., & Swartz, E. (1998). *Doing Research in Business and Management: An Introduction to Process and Method*. London: Sage Publications Ltd.

Sekaran, U. (2003). *Research Methods For Business: A Skill Building Approach*. NY: John WIley & Sons.

Shea, C. M., & Howell, J. M. (1999). Charismatic leadership and task feedback: A laboratory study of their effects on self-efficacy and task performance. *Leadership Quarterly, 10*(3), 375-396.

Taylor, W. A. (1998). TQM implementation: Organisation practices and information infrastructures. *International Journal of Management Science, 26*(6), 715-727.

Taylor, W. A., & Wright, G. H. (2003). A longitudinal study of TQM implementation: Factors influencing success and failure. *The International Journal of Management Science, 31*(2), 97-111.

Wang, E., Chou, H.-W., & Jiang, J. (2005). The impacts of charismatic leadership style on team cohesiveness and overall performance during ERP implementation. *International Journal of Project Management, 23*(3), 173-180.

Wang, X., & Huang, J. (2006). The relationships between key stakeholders project performance and project success: Perceptions of Chinese construction supervising engineers. *International Journal of Project Management, 24*(3), 253-260.

A CONCEPTUAL FRAMEWORK FOR CUTTING DOWN BULLWHIP EFFECT WITH SHARING POINT OF SALE (POS) INFORMATION ACROSS THE SCM

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INTRODUCTION

Relying on effective supply chains in the competitive global market has increased among the companies for achieving success in the network economy (Buchmeister, 2008). Efficient, effective and rapid respond are known as the most important aspects of good supply chains (Kim et al. 2007). In this regard, Buchmeister (2008) believed that although bullwhip effect is not damaging by itself, its results might cause problems in the failure of SCM implementation. According to his study the amplification of inventory level, lack of customer satisfaction, lack of profits, decrease in production level, lack of efficient decision-making, inefficient transportation, increase in costs, "sub-optimal production and transportation" are the main consequences of this phenomenon. According to Kim's et al. (2007) studies, it is possible to support existence of the bullwhip effect by providing empirical evidence, using analytical methods to establish the existence of the bullwhip effect, recognizing the possible reasons of the bullwhip effect and finding proper strategies to eliminate of the bullwhip effect.

METHODOLOGY

In this paper A.T.Kearney Inventory Distribution simulator (Version 1.0b) which is developed by Forrester (2000) is used to evaluate influence of sharing point of sale (POS) data across the supply chain which will reduce demand variation, increase order forecasting abilities, overcompensation and fluctuation of inventories and delays among the supply chains. The advantage of this simulator is possibility of both sharing and non-sharing information among the chains. In this simulator, it is possible to apply inventory adjustment time, sale average time, shipping delay and inventory coverage time data. For running this simulator, authors received real information from four automotive manufacture companies. The average numbers of data is utilized in this simulation (It showed in table 1).

Items	Inventory adjustment time	Sale average time	Shipping delay	Inventory coverage time
Company 1	t= 3-5 (ave. t=4)	t= 2-4 (ave. t=3)	t= 2-4 (ave. 3)	t= 2-6 (ave. 4)
Company 2	t= 4-6 (ave. t=5)	t= 5-10 (ave. t=8)	t= 1-5 (ave. 4)	t= 3-5 (ave. 3)
Company 3	t= 2-4 (ave. t=3)	t= 5-9 (ave. t=7)	t= 3-6 (ave. 5)	t= 2-6 (ave. 3)
Company 4	t= 2-6 (ave. t=4)	t= 3-5 (ave. t=4)	t= 3-7 (ave. 5)	t= 2-5 (ave. 4)

Table 1: Real Information from Automotive Manufacture Companies

Authors ran this simulator at eight stages for 36 weeks which usually apply for beer game. First, it ran in three stages according the traditional beer game which there was not any information sharing and collaboration across the chain; each organization observes the demand pattern of its customer then orders will be placed. In this phase, end customer demands were only visible to the retailer as the end tire which is faced to end customer. Consequently, each tire has to forecasts its own demand lonely. Second, it ran with sharing information across the chain while this information was visible for all tires to make proper decision and forecast their customer demands for all four companies.

The behavior of the orders at three different levels of the chain (retailer, distributer and wholesaler) is shown in the graphs below (figure 1 & 2). Running simulator revealed that, the performance of first & fourth companies and also second & third companies were almost similar together, approximately because of the similarity between their data (According table 1). In this regard authors ignore to describe the same results and just mentioned to focal point differences between the first and second companies. In the traditional mode, orders have dramatic fluctuations across the chain which is shown in figure 1, right for first company and left for second company. In the first company the amount of orders were began from 1400 products at three different levels then raised to about 2000, 2600 and 5500 products for retailer, distributer and wholesaler respectively. Compare to these variations, in the second company, the amount of orders were began from about 700 products at three different levels then increased to about 1800, 2700 and 3300 products for retailer, distributer and wholesaler respectively.

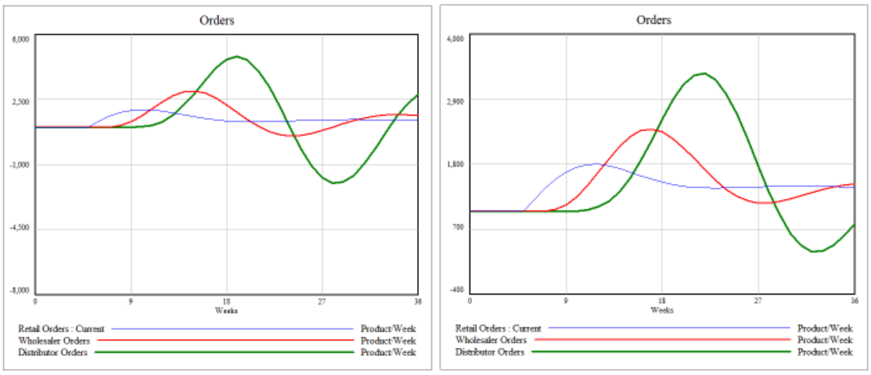

Figure 1: Order fluctuation according traditional beer game

The amount of sale average time data was considerably different in the second company in compare to the first company while the other data almost is similar together (As it showed in Table1). In this regard, the highest numbers of product orders when information is shared, were about 2700 products in the first company (figure2 left) whiles in the second company(figure 2 right) these are reduced to about 1900 products. These consequences revealed that beside of other reasons, sharing sale's information also has influence on the decreasing and increasing orders across the chain which will be created serious problems like bullwhip effect across the supply chain.

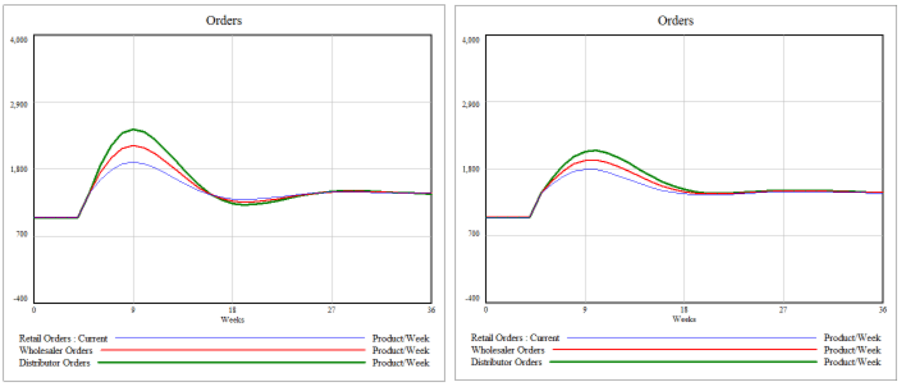

Figure 2: Order fluctuation with sharing information in the beer game

Propose a framework

The basic building blocks of the framework which will be presented in this paper are POS data, Data transmission medium infrastructure like Local area network (LAN) or Internet, Database for storing all data and program to feed in/out data and Web, Third part information and information center as the methods of information sharing.

POS DATA

POS data is used since 1980s by Wal-Mart. Larry Lapide (director of the recently launched Demand Management Solutions Group at the MIT Center for Transportation and Logistics), has mentioned in his interview that POS data was not clean to use at first but it was so suitable when is used by retailers for their replenishment. Furthermore, data are still not usable for consumer's goods and manufacturers because they require harmonizing data with their own language and systems (Balachandran and Morganstern, 2007). Chopra and Meindl (2007); Turban et al. (2005) ; Buchmeister (2008) believed that sharing information across the supply chain has critical role in improving supply chain management performance and decreasing SCM's problems. In this regard, POS data has more beneficial effect on overcoming SCM obstacles. These results are similar to Cooper's (2010) interview with Aguilar, Panasonic's Senior Vice President of Supply Chain Strategic Initiatives who emphasized on sharing POS data as the best solution for demand forecasting and planning in their supply chain management system. As it is indicated in the previous section, improving SCM performance and cracking the bullwhip effect need to; decrease demand fluctuations, to increase the frequency and quality of collaboration, to understand product demand patterns, and to improve partnership and trust across the supply chain management. The POS data lends itself easily to satisfy many of the above criteria. Although researchers tried to overcome the impediments of SCM with sharing information across the chain, it did not solve these problems appropriately regardless of the type of information that should be shared across the chain. The data on customer order such as number of products and customers, kind of service or goods and the delivery time which are known as the POS data, are produced in the sale department in each organization. The important characteristics of these data (POS) are defined as the real time, accurate, accessible and usable information. Companies tend to have uniform safety-stock levels across all categories and regions throughout the product life cycle. Otherwise with significant analysis of POS data, the demand variability and weekly safety stock will decrease. Moreover, according to this method the safety stock will be necessary just for a few intended purposes (Ponoth and Juneja, 2010). Consortium (2003) has developed a questionnaire for Supply Chain Management software solutions, according to this survey; respondents have identified POS Transactions as a methodology for demand variation, order forecasting and Supply Chain Solution.

Database and Security

The Collected logical related records or files which were consolidated into a common pool will present data and information for one or more multiple users. This is known as Database. We always assumed that database is just storage of data; though, for working with database we need a set of programs or tools called database management system (Elmasri and Navathe, 2003). The ability and willingness of information sharing essentially depends on assurance in the security of SCM system. Incentive of different partners, prevention of the anti-trust implication, and insurability of the timeliness and accuracy of information are the most challengeable issues along the information sharing. Moreover, high levels of information sharing might be faced with many security problems across the supply chain (Lee and Whang, 1998). Kros et al. (2005);Anderson & Schwager (2002) revealed that lack of productivity, revenues, loss of willingness and reduced competitiveness are the main consequences of breaking security in SCM. Much possible security attack can threat SCM system information such as inference attacks (at the data management layer), password sniffing/cracking software (at the multiple layers), spoofing attacks (at the network communication layer), denial of service attacks (at the multiple layers), direct attacks (at the multiple layers). Information is shared among different partners and organizations across the SCM system. Recently, Internet which is used in communication and collaboration across the chain is a best solution for the infrastructure facilities. In this regard, all technologies of security and controlling of sharing information are suitable to be used in Internet. General technologies for securing communication network through the Internet include Secure Sockets Layer (SSL), multiple types of Virtual Private Network (VPN), firewalls, vulnerability assessment tools (scanners), intrusion detection systems and security auditing (logging) tools (Kros et al., 2005). On the other hand, new security technologies are generated which are appropriate for security of internal SCM structure such as; Role Based Access Control (RBAC) technology, Secure Supply-Chain Collaboration (SSCC) protocols suite, and Radio Frequency Identification

Technology (RFID) which provide secure information sharing across supply chain management (Zhang and Li, 2006).

Information sharing Mode

Zha and Ding (2005) believed that information sharing modes are mode of knowledgeable information transfer, third Party Mode, Information Center Mode and Web Service Mode. In this paper, authors first used "Web service mode" as a general system to share POS information across the chain for developing framework A. Second, they used "Third Party Mode" and "Information Center Mode" as especial system to share POS information in another framework (B). This framework (B) is suitable for companies which are faced with problems of analyzing POS data in their own organizations. Extensible Markup Language (XML) technology which is used in this paper can make it possible to transfer data among widely disparate programs, to operate systems, and also to represent data by companies as a platform-independent format which enable developers to design their data format with their own requirements and definitions. In fact, authors used the main feature of XML technology for data interchanging (Robison, 2010).

Framework within an individual supply chain tier

First, sale department receives orders from customers. Second, sale's management department should immediately decide either to accept or cancel these demands. In this regard, he receives his requirement data from database through local area network in the company such as inventory level, financial situation and production schedule time to make right and on time decisions. Third, orders which are accepted by sale department's management will be recorded as a part of the point of sale data in the sale department. Fourth, this information (POS) will be sent to database to be used by other departments that will prepare products or services to satisfy customer orders through LAN. Implementing a system for real time and accurate data acquisition would require that all departments in the company to get connected to local area network and have access with database. All information which sends to database should be approved by management of each department to be accurate. All departments must send their information and requirements to the other departments through local area network and eliminate using the hardcopy which takes a long time to be received by other department (Figure 3).All units in the supply chain can follow the sale department framework in their company; therefore, the conceptual framework(A) is proposed by employing sale department framework for all members of a chain based on the division of the beer game such as factory, distributer, wholesaler and retailer which are all connected through Internet together (It shown in the figure 4).

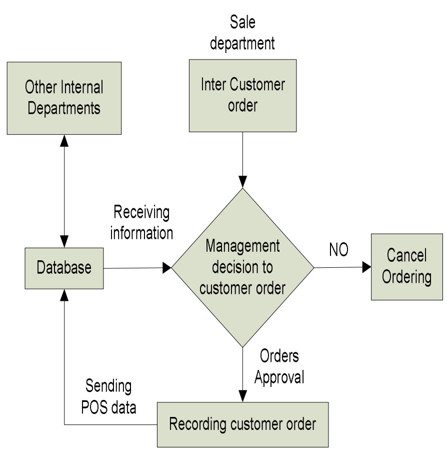

Figure 3: Sale department framework

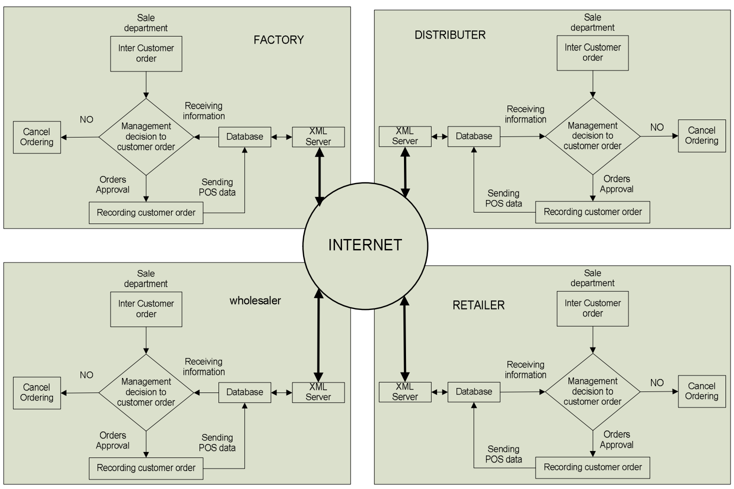

Figure 4: framework (A)

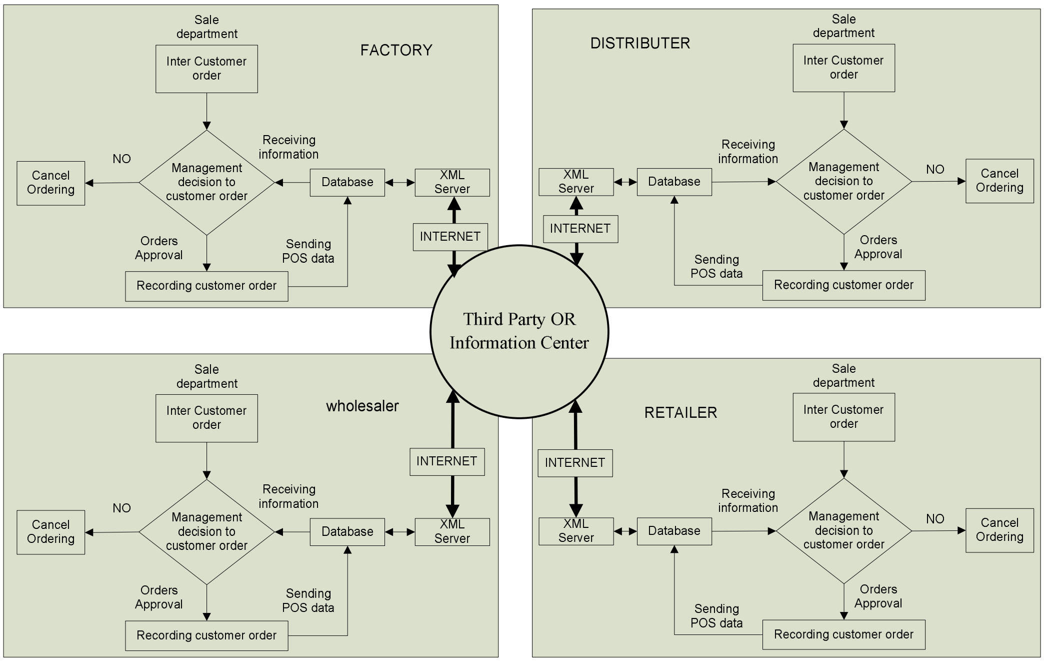

Figure 5: Proposed framework (B) with using Third party or Information Center

It does not matter which software companies use to prepare their information. XML protocol makes it possible to transfer data among the different organizations with the different software. In this framework, for instant a factory can access POS data of all other tires through Internet which connect factory to the other unit's databases. Factory can forecast future demand of customers according to this data.
In this framework (A), all tires have appropriate necessities to analysis all POS data such as knowledgeable employees and proper software. Those organizations which do not have these proper necessities to analysis data appropriately can use framework (B) which is generated according to framework (A). Changing mode of information sharing in the Framework (A) from "Web base mode" to "Third Party" or "Information Center Mode" will create new framework (B). According to these modes all data will be transferred to Third Party or Information Center through Internet which have all necessities to analysis POS data for each tires of chain and send back information to all organizations to make their own decisions in term of order prediction, decrease in demand variations which is a countermeasure of the bullwhip effect (These modifications are illustrated in figure 5).

DISCUSSION

As authors mentioned before, in the beer game all data which ran for the first and second companies were almost the same. Otherwise in terms of sale information, there were significant differences between the two companies. This study revealed that because of dissimilarity on the sale's information, orders' fluctuations were not the same between these two companies. This determines that companies should consider the point of sale data across their chain to be successful on the demand forecasting.

Balachandran, and Morganstern (2007) emphasized that although capability of using real time POS data is the most important key element for organizations to respond effectively to the global market. Most of them require seeing more granular data on a daily basis beside the POS information. For instance, companies need to be able to look at the entire data of their customers, to see as well as to predict the out-of- stocks and to immediately get down to work with their customers on resolving the issues. In this regard, authors revealed that current framework is not only suitable for sharing POS data but also all requirement data are available through database of each company according to their permission and access level of the information which are defined in their contract. Joshi (2000) in his framework proposed using of radio frequency tags, in combination with tag readers to achieve real time data acquisition in the organizations to provide real time information in the inventory level. Authors suggested that tires in the current framework (A & B) mentioned in this paper can use Joshi's framework to provide real time and accurate inventory level information in their database. Especially this is suitable for sale department to make fast decisions to provide POS data for other tires of chain. Furthermore, they can use Feng et al. (2005) model which is presented to improve transportation system for on-time receiving orders from suppliers and responding quickly to customer demands and providing most accurate and real time distribution information for other units of chain.

In today's global market, companies found that cash flow improvements, margin and revenue are depending on how smartly and efficiently they use the power of POS data. Authors believed that achieving real time information will be approached across the chain in the current framework (A&B) when all tiers follow their commitment to send real time data in their database monthly, weekly or even daily. Moreover, POS data can be used to support vendor management inventory (VMI) in each unit of supply chain such as retailer or manufacture which traditionally they have been looking closely into a black hole regarding day-to-day inventory performance. Basically, new VMI is very important not only at the distribution center where all tiers traditionally were involved to manage inventory and replenishment but also at the store level (Balachandran and Morganstern, 2007).

Victoria Cooper (2010) has conducted an interview with Mike Aguilar, Panasonic's Senior Vice President of Supply Chain Strategic Initiatives. This interview revealed that although POS data is the best solution for order and demand forecasting, in the new global market, companies have faced with new problems which they cannot confront by traditional POS data methods. In the new strategy, they convert from being a "sell-in" company to being a "sell-through" company because the real sale doesn't take place when "sell in" method is used for their retailers. In the traditional POS strategy, they collected POS data from their retailers and applied their analysis according to this information, but in the new strategy, they ask retailers to let them help choose what products should be put into their distribution centers on a weekly basis. He mentioned that, we have engaged in a partnership with particular software and technology (i2) which enable us to look at the data more carefully and with more precision than they can. It means that they shift their emphasis from supply to demand, their forecasting to a POS forecasting system and also their focus from supply-side management to POS-managed inventory to be more successful than before in the fierce competition global market. According to Cooper's (2010) interview, each tires in the framework (A) needs analytical IT system to analysis POS data which receive from other units of chain. So, Customer relationship management (CRM) is a best strategy to manage and support business interactions with customers and sales forecasting. It is well recognized and widely-implemented solution in world since 10 years ago. It uses technology for automation, organizing and business processes synchronization sales activities. Also, it can facilitate marketing, customer service, and technical support too. (Gentle, 2002).

Many organizations are not willing to invest on purchasing and using completely and appropriately these tools in their companies for aligning marketing and sales as the best solution. Frequently, for applying these tools, systems separated to individual departments to address their own requires instead of applying total solution. In this regard framework (B) is proposed, to those organizations which cannot implement total system in their companies to analysis POS data which can use "Third party mode" and "Information Center Mod" as the new technique to deal with the lack of appropriate software and knowledgeable employees in their companies.

CONCLUSIONS

Decreasing the costs and demand variability across the supply chain will be achieved by visibility and availability of right and accurate data. In the framework (A & B) which is proposed in this paper, POS data is used as the most accurate and accessible data which should be shared with all the units of SCM. The concept of the beer distribution game is applied to establish this claim that sharing information especially POS data across the supply chain has influenced on the order variations. In the framework (A) "Web base mode" is proposed as a technique for sharing POS information through the Internet for those organizations which are able to analyze POS data in their companies. Moreover, Third party and Information Center Mode are suggested as methods of information sharing in framework (B) to those companies which do not have enough necessities to analyze data in their organizations.

Nowadays, POS data is known as the most beneficial information which must be shared across the SCM to reduce demand fluctuations, to increase the frequency and quality of collaboration and to understand product demand patterns across the supply chain management in the global market. Bullwhip effect as the most important impediment of SCM implementation will be cracked by sharing POS data across the chain when this information is shared along the chain from the manufacturer to the retailer, the manufacturer can use the information about the retailer's sale to manage the frequency, quantity, timing of the shipments and productions instead of waiting for the retailer to place orders. This practice is referred to as Continuous Replenishment Process (CRP).

Although the importance of tracing customer behavior through POS data is identified by supply chain professionals in today's competition global market, very few companies actually use that information. Also sharing POS data by retailers with their suppliers will allow suppliers to control their own destiny, but unfortunately many retailers are not willing to use these data strategically or operationally. The biggest obstacle of using POS data is its huge quantity. The aggregation of all the data can be counted to million pieces of data per day in each tier. Since the user of POS data does not know properly, at the outset, which data are relevant to be analyzed, Sales-reporting tools are produced to analyze the trends and to present pre-defined reports and ad hoc tools to reveal the data. Rapid response to this information needs strong tools and software. The research results can be strengthened in the future by employing more usable software and more knowledgeable employees for appropriate use and analysis of POS data in order to decrease demand fluctuations across the chain. On the other hand, security as the main issue to transfer data should be considered by researchers and practitioners to be stronger and cheaper. Immediate attention in future research should be taken on the impact of the use of Third party and Information Center Mode on analyzing POS data in each unit of SCM. Moreover, In order to evaluate these frameworks, authors are planning to conduct interviews with some companies.

REFERENCES

Anderson J,Schwager P(2002),"Security in the Information Systems Curriculum Identification & Status of Relevant Issues", *Journal of Computer Information Systems*,42:3, pp.16-24.

Balachandran M, Morganstern J(2007) "There is power in POS data-not just for retailer, but for suppliers" [online], *Supply chain leader, [Accessed 8th March 2010],available from http://www.i2.com/supplychainleader/issue4/html/SCL4_theres_power_in_pos_data.cfm*.

Buchmeister B (2008) "Investigation of the bullwhip effect using spreadsheet simulation", *International journal of simulation model,* 1:29-41.

Chopra S, Meindl P (2007) "*Supply Chain Management, strategy, planning, operations,* Third edition", Pearson Prentice Hall.

Cooper V (2010) "Big is beautiful at Panasonic" [online], *Supply chain Leader, available from http://www.i2.com/supplychainleader/issue1/html/SCL1_interview_panasonic.cfm, [Accessed 18th March 2010].*

Consortium T (2003)"2003 Supply Chain Management Software Survey" [online], *available from* http://www.lionhrtpub.com/orms/surveys/scm/scm-surveymain.html, *[Accessed 15th March 2010].*

Elmasri R, Navathe S (2003) *Fundamentals of Database Systems,* fourth edition, Addison Wesley,Pearson .

Feng Ch, YUAN Ch, LIN Y (2005)"THE SYSTEM FRAMEWORK FOR EVALUATING THE EFFECT OF COLLABORATIVE TRANSPORTATION MANAGEMENT ON SUPPLY CHAIN", *Journal of the Eastern Asia Society for Transportation Studies* 6:2837 - 2851.

Forrester N. B. (2000) A.T. Kearney Inventory Distribution Simulator [online], Atlanta, Available from http://web.mit.edu/jsterman/www/SDG/MFS/simplebeer.html, *[Accessed 28th March 2010].*

Gentle M (2002) "*The CRM Project Management Handbook: Buil Realistic Expectations and Managing Risk",* Kogan Page

Joshi Y (2000)"Information Visibility and Its Effect On Supply Chain Dynamics", *Department of Mechanical Engineering, Massachusetts Institute of Technology.*
Kim J , Chang T, Jeong H, Kim K, Park J(2007) "*A Model and Analysis of the Bullwhip Effect Using a SCOR-Based Framework"*, *AsiaSim,* Springer Berlin Heidelberg, *CCIS 5*:12–20.
Kros J, Foltz C, Metcalf C (2005) "Assessing & Quantifying the Loss of Network Intrusion",*Journal of Computer Information Systems***,** 45:2, pp. 36-43.
Lee H, Whang S (1998) "Information Sharing in a Supply Chain",Research Paper No. 1549, Graduate School of Business, Stanford University.
Ponoth S, Juneja M (2010)" Managing products at the shelf level enables retailers to get closer to consumers" [online], *Supply chain leader,[Accessed 10th March 2010].available* *http://www.i2.com/supplychainleader/issue8/departments/shelf-centered-collaboration.cfm*,
Robison L (2010) XML for the Data [online],*[Accessed 23th March 2010].*available from file:///C:/Users/farshad/ERP%20xml/Data%20Management%20Strategies%20%20XML.htm
Turban, Leidner, McLean, Wetherbe (2005) "*Information Technology for Management: Transforming Organizations in the Digital Economy"*, 5th Edition,Wiley.
Zhang Ch, Li S (2006)"Secure information sharing in Internet-based supply chain management system", *Journal of Computer Information Systems*
Zha X, Ding N (2005) "Study on information sharing in supply chain". In *Proceedings of the 7th international conference on Electronic commerce*, Xi'an, China: ACM.

DESIGN OF AN RFID-ENABLED FRESH MEAT RETAIL SUPPLY CHAIN

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ABSTRACT

Purpose: This paper reports on a research project to evaluate the benefits of using radio frequency identification (RFID) in a fresh meat retail supply chain.

Methodology/Design: Value stream mapping (VSM), together with on-site interviews and discussions, was the primary research method for this project. The VSM examined all processes and stages of material and information flows along the retailer's meat supply chain.

Research Findings: Non-value adding activities found included time and labour processes, which in turn led to increased errors. Our future state map suggested RFID technology use with plastic meat trays will increase information visibility, reduce handling and checking, and increase speed.

Research Limitations: The retailer's fresh meat supply chain is complex and long; this project was a pilot and thus suffered from time and geographical distance limitations and does not reflect all supply chain actors.

Practical implications: There are potentially large savings to be had by implementing RFID technology in certain aspects of the supply chain, particularly where information is required for traceability and control of food quality and safety.

Originality/value of the paper: This paper has demonstrated the practical use of a proven technique, VSM, in a different context to highlight the advantages of designing and implementing RFID technology in the food supply chain. The benefits found in this project add to the RFID and supply chain literature and also provide additional evidence to allay RFID scepticism.

INTRODUCTION

RFID is considered a major technological solution to improve supply chain visibility, facilitate product traceability, and improve operational accuracy and manipulation of physical units (Butcher, 2007; Boeck and Wamba, 2008). The food products industry is an area where traceability and control of food quality and safety are crucial and require more surveillance and transparency; management of the fresh food supply chain requires faster decision-making as the quality of fresh agricultural products such as fish, meat, poultry or fruit and vegetables can change rapidly (Regattieri et al., 2007). However, while many retailers believe RFID has a number of benefits to improve overall business performance there are still some that consider RFID technology has not been entirely proven as regards technological and business advantages, particularly in the fresh food supply chain (Vijayaraman and Osyk, 2006).

This project was developed with a major UK grocery retailer to investigate how RFID technology could be used to help improve supply chain performance, eliminate or reduce waste, and save costs in its fresh meat supply chain. The project had two primary objectives: depict the current situation of existing processes along the entire fresh meat supply chain to identify where waste and non-value-adding processes could be eliminated or reduced; and develop a 'future state' RFID-enabled supply chain to identify where RFID technology could add value and possible benefits from time and cost savings.

LITERATURE REVIEW

The adoption of RFID technology is increasing in the retail sector with major retailers such as Wal*Mart and Metro running longitudinal pilot studies and Sam's Club rolling out

RFID to the extent that they now do not accept deliveries that are not RFID tagged at pallet level (Boeck and Wamba, 2008). These early adopters are developing practical RFID applications to quickly gain a return on their investments via improved operational performance. Real-time supply chain visibility and greater information integration are primary benefits of RFID in the retail sector to ultimately increase traceability, reduce logistics costs and lead times, and improve on-shelf availability (Bansal, 2004).

A survey of 130 major organisations in the UK food and grocery industry revealed that over two thirds of those surveyed believed that RFID will deliver a wide number of benefits and improve overall business performance (Clarke et al., 2005). And yet, other research shows that RFID technology has to date not been explored enough (Vijayaraman and Osyk, 2006). Indeed, Dutta et al. (2007) argue that RFID literature has been flooded with generic articles that fail to offer extensive empirical evidence of RFID's benefits. This could however be attributable to the fact that so few retailers are currently adopting RFID. Nevertheless, some significant RFID applications have been empirically tested to identify the following potential benefits of RFID to retail:

- Improved data accuracy and inventory management (Tajima, 2007);
- Reduced stockouts / improved on-shelf availability (Hingley et al, 2007);
- Improved customer service (Tajima, 2007);
- Reduced labour costs (Twist, 2005);
- Reduced shrinkage (Chappell et al., 2003);
- Improved asset management (Butcher 2007).

Further, product traceability along the supply chain in food and grocery retail is critical to providing safer supply of products to the end consumer (Regattieri et al., 2007). Improved food traceability will reduce product recalls (Saunders, 2005) and spoilage (Hingley, 2001) through effective stock rotation and accurate replenishment timing. It is important to note that fresh food quality can deteriorate rapidly, thus fresh food supply chain management requires faster decision-making and improved inventory accuracy and control for quick response to prevent wastage (Jedermann et al., 2009).

Despite these substantial benefits, there remain a number of key challenges in RFID adoption. RFID's current disadvantages include cost, tag availability, technical problems, disposal problems, security and privacy issues and lack of awareness. Jones et al. (2004) also found that key challenges to gaining wider adoption are integration of RFID applications into existing business processes, future relationships with partners i.e. suppliers and distributors, data sharing challenges, the ability to find value in the multiple data captured, and sufficient training of users.

Cost continues to stand out as the key barrier: the cost of RFID tags remains relatively high compared with barcoding. Besides the initial cost of equipment, retraining and integration, the ongoing tag replacement costs are *the* major limitation (Smith, 2005). E.g., using a 5 cent tag on a 50 cent chocolate bar is not feasible. Retailers are therefore focusing on tagging pallet and case-loads (for high value items) instead of adopting item-level tagging. However, the safety and traceability requirements in the fresh food supply chain make it imperative that RFID be moved towards item level in this category.

RESEARCH PROBLEM AND METHODOLOGY

As noted above the key barrier to widespread implementation of RFID is cost. With RFID tags still relatively expensive a positive return on investment (ROI) cannot be delivered without proving significant benefit beyond that of barcoding (Butcher and Lalwani, 2007). This research project aimed to identify where value could be added across the fresh meat retail supply chain to evaluate the potential for RFID to eliminate non-value adding activities and thus enhance the business case for full adoption in retail supply chains where products that are high value, temperature sensitive, short-lifed, and perishable have high health and safety standards to adhere to.

Value stream mapping (VSM), together with on-site interviews and discussions, was the primary research method for this project. The VSM examined all processes and stages of material and information flows along a major UK retailer's fresh meat supply chain to better understand them from the food processor/manufacturer to the store shelf and identify any cost adding and other non-value adding activities (Hines and Rich, 1997; Rother and Shook, 1999). The VSM approach consisted of five stages: collecting data and producing the current state map; evaluate and critique the current state; producing a future state map using RFID technology; producing action plans and recommendations for deployment; and providing a detailed review of expected benefits.

RESULTS AND ANALYSES

A value stream map of the current state of the retailer's fresh meat supply chain, from the meat supplier to the store is shown as Appendix 1. Here we identified a number of non-value adding activities caused by waiting time and human intervention. For example the seemingly essential human tasks of physical checking, scanning, verifying and counting of inventory and trays (i.e. case loads) at the each stage of the supply chain are identified as being non-value adding. RFID automated scanning would eliminate the line of sight requirement of barcode readers and thus eliminate these human-oriented tasks. We now turn to identify specific constraints.

At the supplier's site

The fresh meat supplier in Preston, Lancashire supplies fresh lamb meat to the retailer's Chilled Distribution Centre (CDC) in Wakefield, West Yorkshire on a daily basis with a frequency of one direct delivery per day. The price level varies depending on the product assortment, which could include shoulder, leg, chops and various other joints of meat. To maintain quality and freshness the meat must be chilled to at least +2°C. All meat is packed in plastic containers and supplied in reusable plastic trays, which vary in shape and size. The retailer supplies these reusable trays to the meat supplier from their Wakefield Service Centre where a tray washing facility is provided.

The information flow between the retailer and their meat supplier is transmitted via Electronic Data Interchange (EDI) mailboxes. Initially, generic supply orders are raised a number of weeks before based on forecasts, but final more accurate (small batch) orders are raised a few days before product is required, based on actual demand.

After order picking and packing at the supplier's site, the supplier prints barcode labels that hold the order number, delivery date, product type, weight, quantity, etc, and attaches these labels to the trays to identify products in the trays. One further label is then issued to identify the whole delivery. The trays are then stacked on pallets or put on dollies (i.e. carts or trolleys) and readied for dispatch to the retailer's CDC.

At this stage the VSM analysis identified labour-intensive, time consuming and non-value adding activities in the supplier's operations such as excessive label scanning, verifying and counting of products. Such duplication of effort and multiple handling, whilst maintaining quality assurance, has an impact on order lead time and cost.

Further, after the daily order has been dispatched, the supplier does not gain any information about that shipment from the retailer. Hence the supplier can only react to orders, and the daily cycle begins again the following day.

At the retailer's CDC

The Wakefield CDC is designed for the storage and distribution of fresh and frozen products and houses three distinct operational areas: the frozen products operation (-25°C), the chilled products operation (+2°C, with which we are concerned in this research), and the ambient products operation (+13°C). This CDC supplies a number of retail stores through Lancashire, Greater Manchester and Yorkshire. All deliveries from the CDC to stores are via direct deliveries by in-house distribution services, with each truck containing a variety of products destined for each particular store.

Before arrival of a meat shipment to the CDC the warehouse operations staff waiting on delivery from the supplier can only know what is in the truck trailer based on the order information they have from their information system. Only after the truck's arrival and opening of the trailer doors can they correlate that information with the actual delivery. They then check what products actually arrived, the quantity, and they confirm the delivery with the information system. Interviews with staff found that inventory errors are not common but can still occur. This obviously leads to non-value adding activities to inform the supplier and make adjustments to the current (i.e. concessions) and possibly subsequent orders.

Upon arrival at the CDC one tray from each pallet or dolly is barcode scanned. Other trays are physically counted in order to confirm product delivery, to check the quantity of products and the accuracy of the delivered order. Each inbound delivery from the meat supplier contains a variety of products for several buyers' (i.e. store) locations. Being fresh meat products with a short shelf life, they stay at the CDC no more than 2-3 hours. During this time the received products will be cross docked with store-specific orders being picked, packed and consolidated with other products newly arrived or held within the CDC to create outbound shipments to the stores. After the cross docking, the system generates new barcode labels to associate products with stores. These new barcode labels are then scanned and the deliveries for each store are checked and counted before loading the trucks and dispatching to the retail outlets.

The VSM analysis identified labour- and time-consuming non-value adding activities here, such as: duplicate barcode scanning, verifying and counting of products. This is a by-product of potential inbound quality issues discussed above.

At the retail store
There is no product or tray scanning upon arrival at the store. Instead, visual counting and confirmation against order are performed. Next, the fresh meat is placed in the back-of-store chiller until front-of-store shelf replenishment is required. Replenishment is triggered by visually monitoring product availability at the shelves. When required, operational staff move full trays of meat from the chiller to the shop floor to replenish the amount required (not necessarily a full tray-load). Strict standards of food product freshness are observed. Meat products must not be in an environment above the maximum chilled temperature of +2°C for more than 20 minutes, thereby limiting the replenishment process time. After shelf replenishment, the trays are returned to the chiller with the remaining meat that was not used.

At the store, ineffective use of labour resources and time-consuming checking and counting were identified in our VSM analysis. Replenishment is also dependent on staff and is thus prone to human error.

At the tray washing facility
When the reusable trays are empty, back-of-store personnel collate them to form pallet-loads. These are then transported to a central tray washing facility at the retailer's service centre where the trays are washed and packed onto a truck for redistribution to suppliers. Trays are dispatched to suppliers based on order information they provide. If extra trays are required the suppliers will request them. There are currently no data on asset shrinkage (i.e. lost trays) through this process because there is no application that controls the movement of trays. It is acknowledged that trays do go missing. This leads to increased handling costs, increased tray recycling lead time, excessive tray inventory, shrinkage and attrition of trays, and substitute tray costs.

DISCUSSION
From our current state VSM in appendix 1, we calculated the total lead time to be 3 hours and 17 minutes, where the total value adding time is 2 hours and 55 minutes (not including transport lead times between nodes). The non-value adding activities we identified include duplicate barcode scanning, counting, checking and verifying at the each point along the supply chain. Each of these activities are prone to human error. Key deficiencies that lead to non-value adding activities such as duplicate inventory counting are a:

- Lack of information visibility;
- Lack of information sharing between partners;
- Lack of inventory and reusable assets visibility between various supply chain nodes.

As discussed in our literature review, RFID offers improved product traceability over conventional barcoding. Further, RFID can reduce human intervention in the scanning, counting, checking and verifying of inventory by locating RFID readers at key points in the supply chain such as at CDC inbound and outbound dock doors. We therefore used the current state VSM to identify where RFID readers might be installed. Our findings are illustrated in the future state VSM in appendix 2. We estimate the future state total leadtime to be 2 hours and 47 minutes, where the total value adding time is 2 hours and 45 minutes. Thus we find that the implementation of RFID for product traceability in this supply chain will offer a 15% reduction in total leadtime and a 6% reduction in value-adding time.

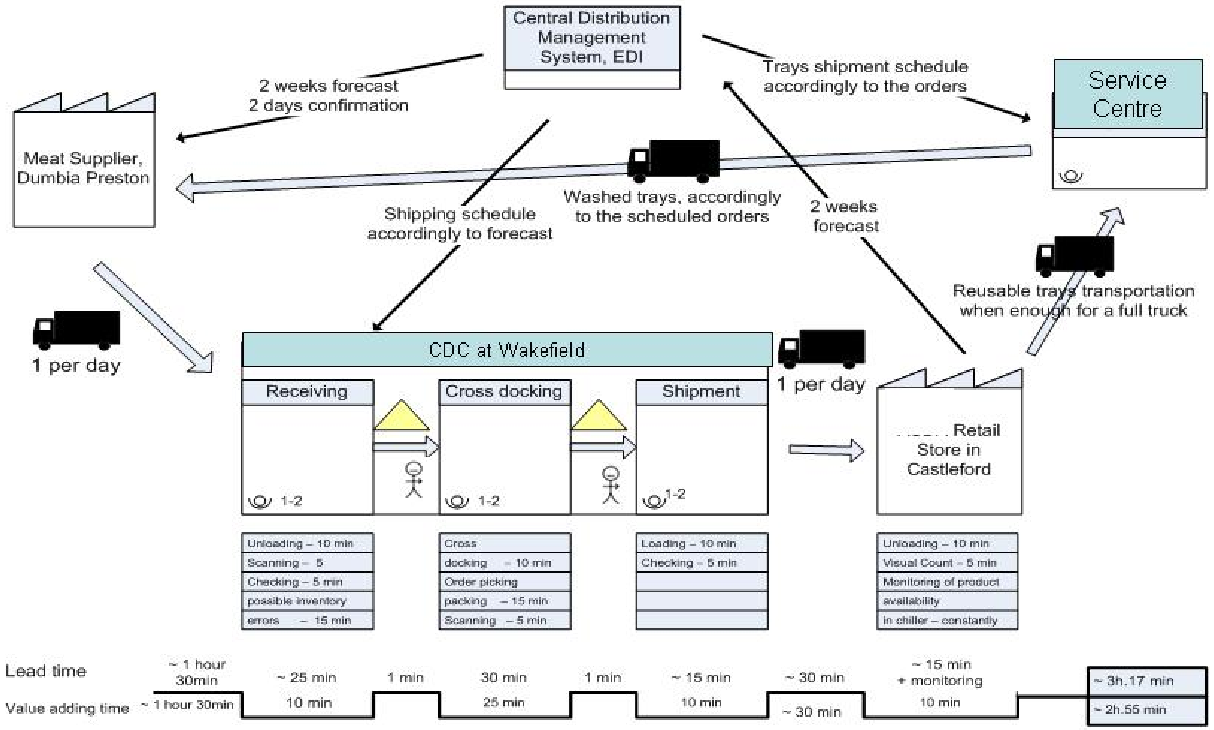
CONCLUSIONS
This research project identified the non-value adding activities associated with attempting to ensure product quality, safety and traceability. For meat products, these are paramount considerations, and thus operational effectiveness and efficiency are traded-off in conventional human-oriented distribution. Yet, through our analyses we found that RFID technologies offer an opportunity to remove this conventional trade-off. The removal of human intervention in product scanning, counting, checking and verifying can enable improved delivery performance whilst maintaining product safety and quality assurance.

This research was undertaken as a precursor for a pilot study to implement RFID in this supply chain. The pilot study will later verify whether or not the timesavings we identified are actually achievable. It will also determine whether or not a return-on-investment can be achieved. Yet regardless of this, food safety is a primary concern for consumers. This is why this retailer is considering RFID for this type of product. Thus, we are likely to see an increasing number of retailers applying RFID to such high value, safety critical products whether or not they can achieve a return-on-investment. This can only be a positive for RFID and supply chain research, whilst the cost of tags remains relatively high, and the main barrier to wider adoption of the technology.

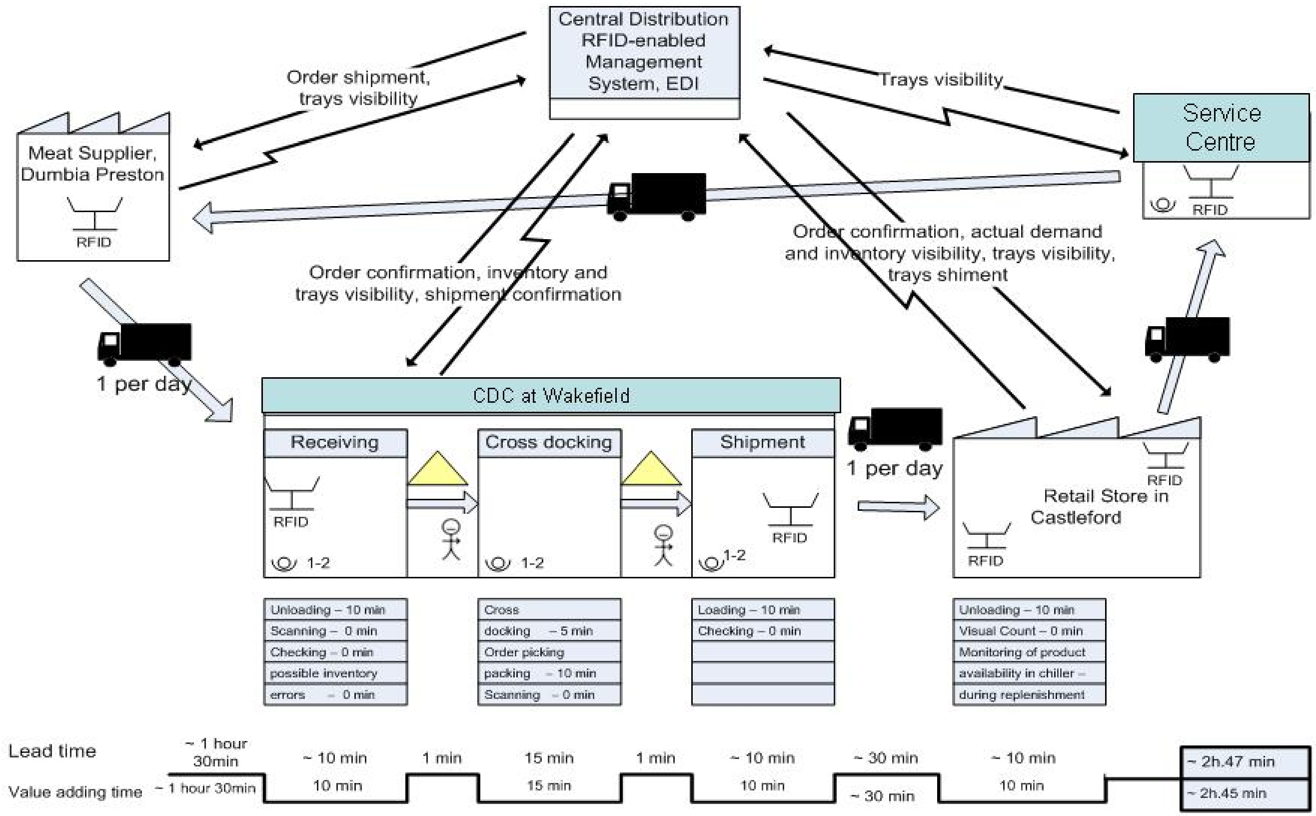
REFERENCES

- Bansal, R. (2004), "Now you see it and now you don't [RFID technology]," *IEEE Microwave Magazine*, Vol. 5, No. 4, pp.32-34.
- Boeck, H. and Wamba, S.F. (2008), "RFID and buyer-seller relationships in the retail supply chain," *International Journal of Retail & Distribution Management*, Vol. 36, No. 6, pp.433-460.
- Butcher, T. (2007), "Radio Frequency Identification: an enabler of agile supply chain decision-making," *International Journal of Agile Systems and Management,* Vol. 2, No. 3, pp.305-320.
- Butcher, T. and Lalwani, C. (2007), "RFID benefit beyond ROI: lessons from a not-for-profit cooperative organisation", *Proceeding of the Annual Conference of the Logistics Research Network*, Hull UK, 5-7 September.

- Chappell, G., Durdan, D., Gilbert, G., Ginsburg, L., Smith, J. and Tobolski, J. (2003), "The Value of Auto-ID Technology in Retail Stores," *Auto-ID Centre,* http://www.autoidlabs.org/single-view/dir/article/6/143/page.html accessed 10/9/2009.
- Clarke, D., Gosain, S. and Thillairajahn, V. (2005), "Realizing the promise of RFID," http://www.ebizq.net/topics/rfid/features/6165.html?&pp=1 accessed 9/9/2009.
- Dutta, A., Lee, H. and Whang, S. (2007), "RFID and Operations Management: Technology, Value, and Incentives," *Production and Operations Management*, Vol. 16, No. 5, pp.646-655.
- Hines, P. and Rich, N. (1997), "The seven value stream mapping tools," *International Journal of Operations and Production Management*, Vol. 17, No. 1, pp.46-64.
- Hingley, M. (2001), "Relationship management in the supply chain," *International Journal of Logistics Management,* Vol. 12, No. 2, pp.57-71.
- Hingley, M., Taylor, S. and Ellis, C. (2007), "Radio frequency identification tagging: Supplier Attitudes to Implementation in the Grocery Retail Sector," *International Journal of Retail and Distribution Management,* Vol. 35, No. 10, pp.803-820.
- Jedermann, R., Ruiz-Garcia, L. and 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.
- Jones, P., Clarke-Hill, C., Shears, P., Comfort, D. and Hillier, D. (2004), "Radio frequency identification in the UK: opportunities and challenges," *International Journal of Retail & Distribution Management*, Vol. 32, No. 3, pp.164-171.
- Murphy-Hoye, M., Lee, H. and Rice, J. (2005), "A real-world look at RFID," *Supply Chain Management Review*, Vol. 7, No. 5., http://www.scmr.com/article/CA6249661.html accessed 11/9/2009.
- Regattieri, A., Gamberi, M. and Manzini, R. (2007), "Traceability of food products: General framework and experimental evidence," *Journal of Food Engineering*, Vol. 81, No. 2, pp.347-356.
- Rother, M. and Shook, J. (1999), *Learning to See: value stream mapping to create value and eliminate muda*, The Lean Enterprise Institute, Boston, MA.
- Smith, A. (2005), "Exploring radio frequency identification technology and its impact on business systems," *Information Management and Computer Security*, Vol. 13, No. 1, pp.16-28.
- Tajima, M. (2007), "Strategic value of RFID in supply chain management," *Journal of Purchasing and Supply Chain Management,* Vol. 13, No. 4, pp.261-273.
- Twist, D. (2005), "The impact of radio frequency identification of supply chain facilities," *Journal of Facilities Management*, Vol. 3, No. 3, pp.226-239.
- Vijayaraman, B. and Osyk, A. (2006), "An empirical study of RFID implementation in the warehousing industry," *The International Journal of Logistics Management*, Vol. 17, No. 1, pp.6-20.



Appendix 1: Current State Value Stream Map



Appendix 2: Future State Value Stream Map and RFID-enabled Scenario

SUPPLY CHAIN FRAGILITY: A CASE STUDY OF ABNORMAL LOAD TRANSPORT FROM SOUTH AFRICA TO UNITED KINGDOM

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INTRODUCTION

Given the relevance of globalization, numerous proposals for configuring the seamless flow of goods in a supply chain as well as guidelines for supply chain vulnerability and risk mitigation have been published. With the aim of creating secure and robust flow of goods in the current arduous trading environment, common commercial decision criteria such as cost and schedule reliability are replaced by other criteria, especially in the case of goods which are extremely high in value and irreplaceable. Less tangible factors such as intuition and risk awareness have become critical in handling fragile cargo and, by implication, the potential fragility of the entire supply chain. In this case study, transport and intermodal transfer of a classic locomotive as an abnormal load from South Africa to Scotland, UK, is presented with a detailed examination of the risks that are involved at each individual point of operation.

A multilateral case study approach in identifying critical operational factors in a range of commercial environments is employed reflecting the transport of the locomotive. The fragility of the product itself constrains the transport options, and there are several scheduling points that are highly critical in intermodal transfer. The research demonstrates that, in the case of high value, irreplaceable, easily damaged goods, logistics cost is less important than risk avoidance. The research enables tentative conclusions to be reached concerning the ranking of critical supply chain success factor in the case of fragile cargoes.

By means of such illustrative case studies, various contexts of risk can be found with more than one solution, each indicating a level of trade-off. In this paper, a case study of transport and intermodal transfer of a classic locomotive, as an abnormal load from South Africa to Scotland, UK is presented with detailed examination of the risk that is involved at each individual point of operation.

BACKGROUND

In research on supply chain fragility, reliability is defined as the consistency of the transit time, costs, service and quality that a carrier provides (Chao et al, 2009; Coyle et al, 2003; Rodrigues, et al 2008). These determinants are as important as commercial factors in governing the decision making process of shippers. Other factors which may directly affect transport operations include events such as terrorism, industrial action, disease epidemics, severe weather conditions, or more indirectly through government interventions such as taxation changes or new regulations (Rodrigues et al 2008). The term, supply chain fragility, has gained momentum since the September 11 2001 crisis. According to Waters (2007), supply chain fragility can be divided into two broad areas:

- Commercial vulnerability – where uncertainty affects the demand for goods in a business environment, where demand fluctuates according to taste, the season or confidence. Other naturally varying causes are often semi-predictable such as traffic congestion and these affect the supply side.

- Non-commercial vulnerability – where uncertainties are dramatic, often longer term, and have greater amplitude, derived from an external shock such as terrorism or war or from severe weather, earthquakes or other natural phenomena.

Fragility is at its maximum and in this case logistics services operate largely on a 'learning by doing' basis during the first few days or weeks following the transport assignment (Beresford and Pettit, 2005). Waters (2007) captures the key dimensions of risk by suggesting that four main forms of uncertainty can be observed:

- **Certainty** – what is known and what will happen beyond reasonable doubt
- **Uncertainty** – events (such as bridge failure, cargo loss/damage) will happen but probabilities cannot be given
- **Ignorance** – doubt over what may or may not happen
- **Risk** – certain events (extra vehicles needed) will happen and can be given a probability

The term 'Intermodal Transport', more commonly known as 'Intermodality', defined by Hayuth (1987), as the "movement of cargo from shipper to consignee by at least two different modes of transport under a single rate, through-billing, and through liability". The purpose of the concept is to further imply cooperation and coordination through the entire transport chain in the most cost- and time-effective manner. In comparison with 'Combined Transport', intermodal transport draws a wider application in other possible combination of transport modes rather than just road-rail (Lowe 2006). Based on the terminology of Combined Transport, the difference between intermodal and combined transport lies in the operational aspects of handling the goods.

In North America, the term 'Intermodality' has been accepted as "the science that deals with the movement of goods between and among various mode of transport." For Lowe (2006) the terminology refers to the utilisation of two or more 'suitable' modes in forming an integrated transport chain, which is aimed to achieve operational efficiency and cost-effectiveness in delivery of goods in an environmentally sustainable manner from their point of origin to their final destination. Similarly, D'Este (1996) also refers to intermodal transport as a framework of multiple perspectives (technical, legal, commercial and management) for moving goods from door-to-door using more than one mode of transport. However, he emphasises that intermodality is more of a service rather than a technology where attention should be drawn towards the facilitation of the 'soft' aspects of transport. On the other hand, according to Murphy and Daley (1998), the terminology is defined as a process rather than a framework or concept.

Furthermore, other authors define the terminology on the basis of the specific combination of modes such as rail-road and vice versa (Nozick and Morlock, 1997; Evers, 1994; Taylor and Jackson 2000). It has been found that these authors share a common understanding of its fundamental nature in involvement of various modes. However, there has not been standard definition for intermodal transport. These definitions differ in the type of characteristics and relationships that authors find relevant in serving the purpose of one's own research (Bontekoning, et al. 2004). In this research, the term 'Intermodal Transfer' will be used as the bridge-link between transport modes.

METHODOLOGY

Routeing analysis of a South Africa to Scotland corridor is chosen as an illustrative case study in order to present the supply chain fragility of a transport operation. A classic locomotive, which was transported from UK to South Africa in the early 20th century during the Second Boer War by the British army, was originally deployed to serve military logistics purposes. After the war, the locomotive was then converted to cargo and passenger transport serving important cities and industrial states. Recently, this classic locomotive celebrated its 100th birthday and the UK government decided to bring this 'historical antique' back to its origin.

In this paper, data were collected using commercial source and field investigations. Observations were made at the research site and interviews were conducted with transport operators. To appreciate the distinct view points for each individual leg, interviews with stakeholders were undertaken to gain perspectives of the risk and fragility elements each transfer site.

FINDINGS: ROUTEING ANALYSIS OF SOUTH AFRICA TO SCOTLAND CORRIDOR

In this section, analysis routeing will identify critical factors through a multilateral examination of abnormal goods transport from South Africa to Scotland. On this particular route (Figure 1), five distinct intermodal transfers are identified, namely, Bloemfontein-Durban leg, Holding yard-Dockside (Durban) leg, Durban-Hamburg (deep sea shipping) leg, Hamburg-Immingham (short sea shipping) leg and Immingham-Glasgow leg. To the best of authors' knowledge, no detailed research into the fragility dimension of this particular route has been conducted, especially with regard to locomotive transport. Here, on the South Africa to United Kingdom corridor, both fragility and risk are often found to be decisive. For the case study, the fragility of the product itself constrains the transport options, and there are several scheduling points that are highly critical in intermodal transfer.

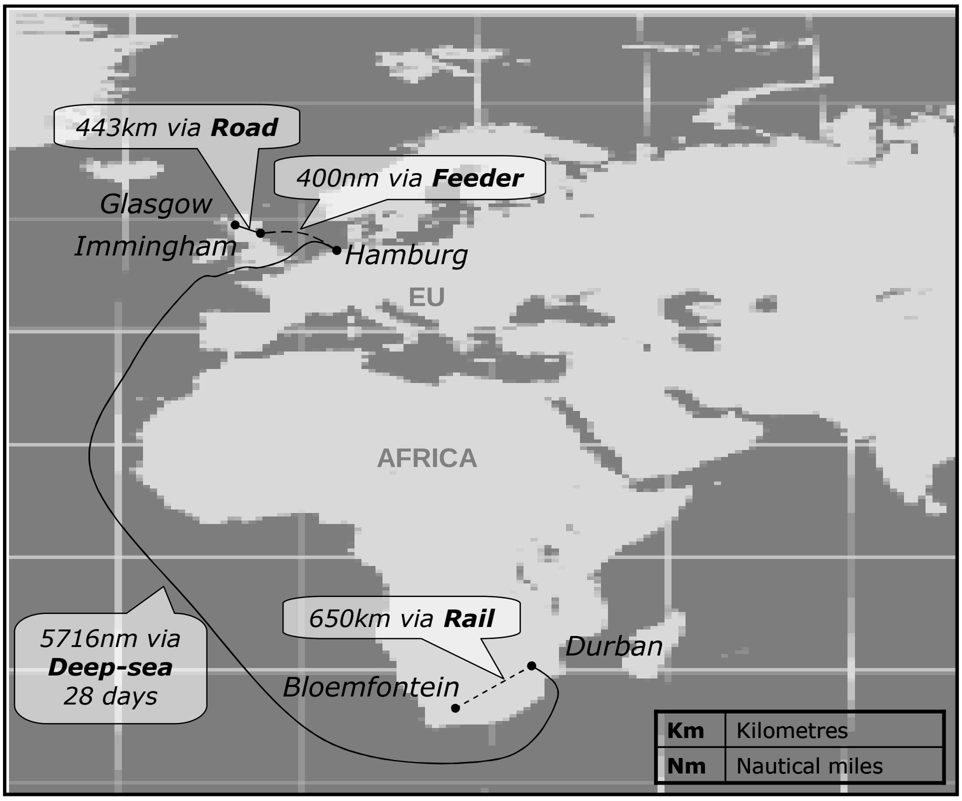

Figure 1: South Africa to UK Corridor

Initial Destination Point

The first issue relate to the initial distribution point which was located in Bloemfontein; capital city of the Free State Province of South Africa. As the locomotive was located near to capital rail station in Bloemfontein and with the line extending to the sea port at Durban, rail transport was the most obvious choice of transport. The distribution of six flat wagons via rail transport would require extra breaking to ensure the stability on the cargo bogie, as the locomotive weighs approximately 103 tonnes. According to the field investigation and interview, four main options were available for handling the rail transport operation between Bloemfontein to Durban.

The first option was to physically run the locomotive under steam along the rail lines. This was a logical choice but the poor condition of the locomotive meant that it was unlikely to be able to sustain a trip of such length without hindering performance issues which could have resulted in serious damage to the locomotive itself. The second option was to dismantle the locomotive into transportable parts. This would provide high flexibility in transporting the locomotive by either road or rail. However, this would have incurred both high cost and time. Issues which might have lead to the risk of missing the shipping schedule. Road haulage was considered as the third option via piggy-back-low-loader but the weight and size of the locomotive, and the poor road infrastructure meant that the road could not support its weight and size. Road conditions from Bloemfontein to Durban port are inadequate in width, poor road surfaces and weak bridges. Furthermore, according to field investigation, police permission for road transport was refused and therefore transport by rail was the only option. The final option was to shunt the locomotive via freight lines and rural routes. This was considered as one of the fastest options because it would allow the locomotive to be transported at up to 90 kilometres per hour (kph). However, this would be regardless of the conditions of the locomotive. According to the condition of the locomotive, it would not be possible to travel at 90 kph continuously for 650 kilometres (distance between Bloemfontein to Durban sea port) due to the risk of overheated bearings. This option required, the rail operator to stop and check every 25 kilometres; have an extremely time consuming option which could have resulted in missing the shipping schedule. Due to the value of the locomotive, the last option was selected.

As the UK government (consignee) demanded preservative of the condition of the locomotive as close to the original as possible, the first three options would not be viable due to the risk of damage to the original condition of the locomotive. Therefore, the transport operator had to shunt the locomotive at 90 kph via freight lines and stop every 25 kilometres to avoid overheated bearings. A summary of the initial leg is illustrated in Figure 2.

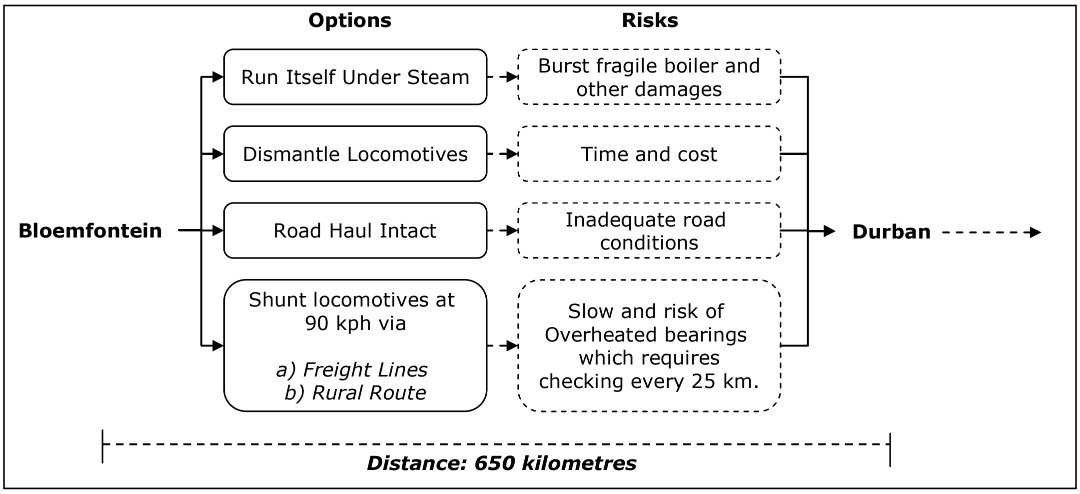

Figure 2: Bloemfontein – Durban

Intermodal Transfer at Durban

The second key area of conflict occurred, when the locomotive reached the holding yard at Durban where intermodal transfer from rail to sea was required. In this particular process, around 20 people would be required together with the use of an extra heavy floating crane to physically lift the locomotive from the train on to a dedicated floating platform. According to the field survey, seven possible risks were identified (Figure 3). However, due to the irreplaceable nature of the locomotive, avoidance on any possible damage to it was considered as the most important determinant of the key success factor of this particular transport operation. Due to the delicacy of the floating platform, finding the right crane size was considered as one of the most challenging tasks. Due to inadequate crane size available at the Durban dockside, this particular task resulted in three lift attempts with some damage to the crane itself. This particular operation took approximately 16 hours which resulted in departure delay.

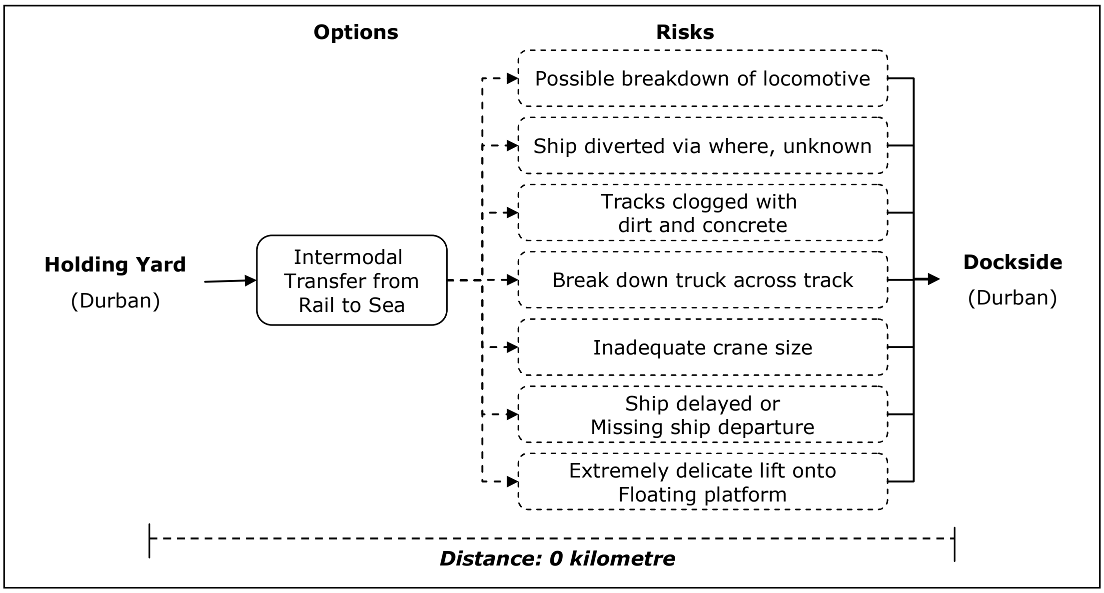

Figure 3: Holding Yard – Dockside (Durban)

Thirdly, the locomotive was carefully placed on the dedicated floating platform and the deep sea shipping is required to perform long-haul transport from Durban to Hamburg. The distance between Durban and Hamburg is approximately 5,716 Nautical miles (10,587 kilometres), which is a 28 day. Due to the amount of lead time required, risk of unpredicted gales breaking the locomotive free would severely damage the goods or the ship itself. Therefore, careful inspection was required prior to departure (Figure 4). The locomotive was placed near the rail of the ship with a dedicated belt to fasten the locomotive to the platform of the ship.

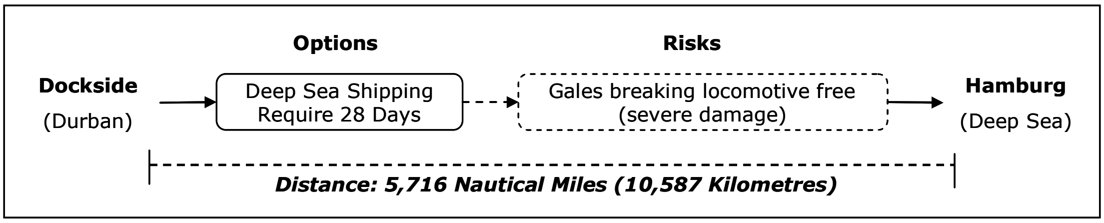

Figure 4: Durban – Hamburg

When the vessel reached Hamburg, transferring the locomotive from the vessel to the feeder with a low-loader was required. The feeder was a vehicle carrier with dedicated hatches to roll-off the low-loader when at berth. Due to the lack of equipment in the port at the final port destination (Immingham), the locomotive had to be unloaded at Hamburg where a wider range of equipment options were available. As the size of the locomotive is 103 tons, the 100 tonne crane would not be possible. The 200 tonne crane capacity would be possible but due to insufficient rut revels. (arms of the crane did not have enough clearance to the feeder vessel). Therefore, the 1000 tonnes crane was used. A summary of the Hamburg – Immingham leg is illustrated hereunder in Figure 5.

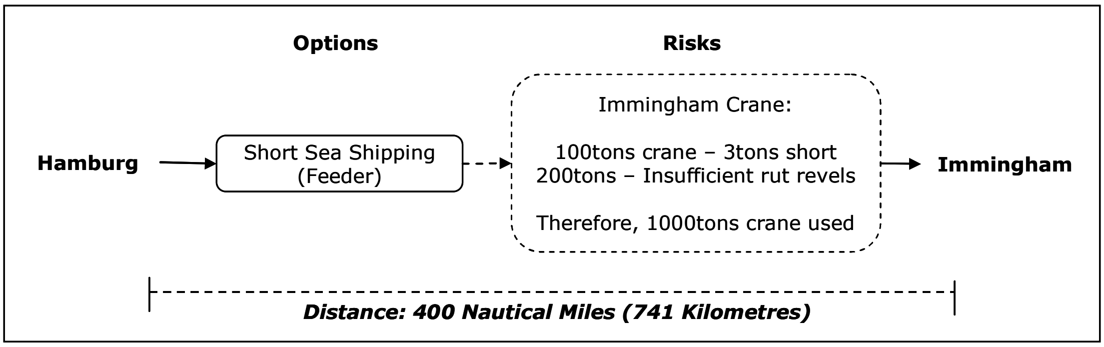

Figure 5: Hamburg – Immingham

Lastly, when the feeder reached Immingham, a heavy-duty truck trailer was used to drag the low-loader off the feeder platform. Road transport from Immingham to the final destination of Glasgow was then took place a distance of approximately 443 kilometres. Due to the length of the locomotive, the local authorities refused permission for the road trailer to move during the day with regard to the height of the locomotive, when placed on the low loader, it had only a 3 inch clearance from same bridges, leaving little room for error. As the width of the low loader was approximately the full width of a single lane, polica assistance was required to ensure that the transport of the locomotive could proceed in a safe environment (Figure 6). As a result, the truck trailer was only able to travel 60 kilometres per hour with the assistance of local police authorities and finally reached Glasgow after approximately 8 hours.

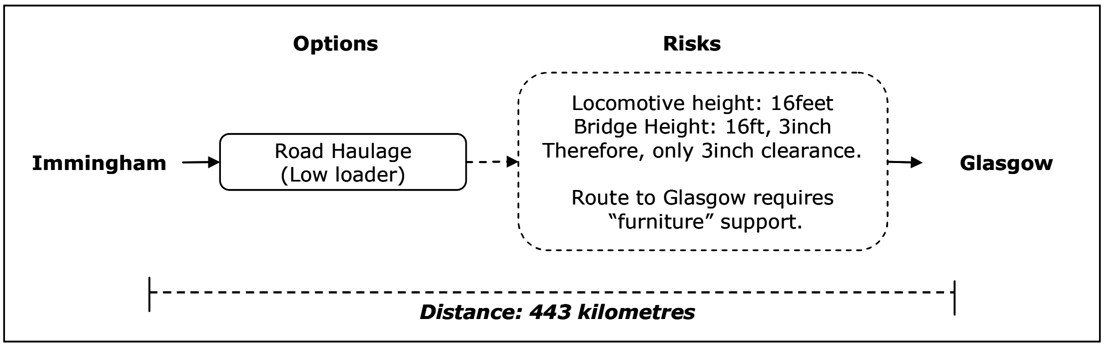

Figure 6: Immingham – Glasgow

Transport of the locomotive took 33 days in total without any delays. Any delays at port, would increased the journey time by between 3 days and 14 days. According to the field investigation, the condition of the locomotive appeared to be rail worthy due to its length of service since the early 1900s. As the UK government signed an official contract with South Africa to bring back the locomotive to its origin a cost factor analysis was not possible due to confidentiality. However, the transport of locomotive has portrayed the transport fragility aspect of this particular supply chain.

CONCLUSIONS

We have presented the supply chain fragility aspect of the locomotive assignment. Problems of risk were exhibited in the transport of the locomotive from South Africa to Scotland UK with an approximate total distance of 12,421 kilometres. The analysis of risks has portrayed the soundness of infrastructural conditions at each intermodal transport point. It was found that the fragility of the product itself constrained the transport options, and there were several scheduling points that are highly critical in intermodal transfer. This research has demonstrated that, in the case of high value, irreplaceable, easily damaged goods, and the logistics cost is less important than risk avoidance. Regarding the condition of the locomotion, usage of sub optimum modes or modal mix is applied to best preserve the condition of the locomotive, regardless of the cost. According to the physical characteristics of the locomotive, 'bad-fitted' or inappropriate equipment are used due to lack of dedicated tools to complete the job. For example, the 1,000 tonnes capacity crane was used due to the lack of specific equipment to accommodate the weight of the locomotive. This resulted in excess capacity wastage of the equipment used. This research is limited to authors' observation and analysis. However, this enables tentative conclusions to be reached concerning the ranking of critical supply chain success factor in the case of fragile cargoes.

REFERENCES

Beresford, A.K.C. and Pettit, S.J. (2005), 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.

Bontekoning, Y.M., Macharis, C. and Trip, J.J. (2004), Is a new applied transportation research field emerging? – A review of intermodal rail-truck freight transport literature. *Transportation Research Part A,* No. 38, pp.1-34.

Chao, P., Piboonrungroj, P. and Beresford, A.K.C. 2009. Transport Reliability of Containerised Agricultural Goods From Thailand to China: A Shippers' Perspective. *Proceedings of the 14th International Symposium on Logistics (ISL)*. 5-8 July 2009, Istanbul, Turkey.

Coyle, J.J, Bardi, E.J. & Langley Jr, C.J. (2003), *Logistics relationships and third-party logistics*. The Management of Business Logistics: A Supply Chain Perspective. 7th ed. Thomson South-Western.

D'Este, G. (1996), An event-based approach to modelling intermodal freight systems. *International Journal of Physical Distribution & Logistics Management.* Vol. 26, No.6, pp. 4-15.

Hayuth, Y. (1987) *Intermodality: Concept and Practice*, Lloyd's of London Press, London.

Lowe, D. (2006) *Intermodal Freight Transport.* Elsevier Limited. USA.

Murphy, P.R, and Daley, J.M (1995), International freight forwarders: current activities and operational issues, *International Journal of Purchasing and Materials Management*, Vol. 31 No.3, pp.21-7.

Nozick, L.K. and Morlok, E.K. (1997), A model for medium-term operations plans in an intermodal rail–truck service, *Transportation Research A,* Vol. 31 No. 2, pp. 91-107.

Evers, P.T. (1994), The occurrence of statistical economies of scale in intermodal transportation, *Transportation Journal*, Vol. 33 No. 4, pp. 51-64.

Rodrigues, V.S., Stantchev, D., Potter, A., Naim, M. and Whiteing, A. (2008) Establishing a transport operation focused uncertainty model for the supply chain. *International Journal of Physical Distribution & Logistics Management* Vol 38 No. 5 pp 388-411.

Taylor, J.C. and Jackson, G.C. (2000), Conflict, power, and evolution in the intermodal transportation industry's channel of distribution, *Transportation Journal,* Vol. 39 No. 3, pp. 5-17.

Waters, D. (2007), *Supply Chain Risk Management*, Kogan Page, London, 256 pp.

MANAGING RISKS IN NEXT GENERATION SUPPLY CHAINS: A SYSTEMS APPROACH

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ABSTRACT
Supply chain risk management follows three basic processes to manage supply chain risks: Identify, Assess and Mitigate. This paper considers a systems perspective towards managing these risks. It presents variables that may affect Next Generation Supply Chains and applies a System dynamics modelling approach (Oehmen, et. al. 2009) towards depicting the causal linkages of these variables with future supply disruptions. To understand the interdependencies within these factors and the risk propagation on account of these factors it was decided to adopt a systems perspective. This perspective is based upon application of a causal loop diagram which considers the interdependencies between the factors affecting next-generation supply chains. The causal linkages between the variables are then highlighted with regards to the supply chain process and the nodes, and the causes of future risks are identified.

INTRODUCTION
The global business environment today is influenced by financial instability, increased outsourcing, mergers, new technologies, e-business, shorter time-to-market, reduced product lifecycle, make-to-order strategies, pull systems, uncertainty, thus forcing organizations to adopt new ways of doing business (Stefanovic *et al*., 2009). Competition today implies that products and services must be improved not only on the basis of Quality, Lead time and Cost, but also on the basis on environmental sustainability, ethical norms, etc. in order to stay profitable. Next generation supply chain management is expected to not only consider the forward supply chain but also consider equally or even more the reverse supply chain due to its economic impact and stricter sustainable legislations. However, these new approaches to handle supply chains have developed complexity, and uncertainty and may also lead to disruptions. Supply chain disruptions affect not only the cost to the supply chain stakeholder, but also their risk profile (risk-return trade-off). In order to handle uncertainty regarding supply chain disruptions, the stakeholders need to utilise various operational risk-management tools and techniques, and may also design risk information-sharing contracts. This paper considers a systems perspective to understand the implications of next generation challenges for supply chains, the associated risks and provide insights into managing the risks.

A supply chain consists of numerous links interconnecting vast networks and these links are exposed to various operational risks as well as disruption risks (Craighead *et al.,* 2007) Operational risks are referred to inherent uncertainties such as uncertain customer demand, uncertain supply and uncertain cost whereas disruption risks are referred to major disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, volcanoes, terrorist attacks (Tang, 2006). Supply chain risk management consists of four management processes:
(1) Identifying the risk sources and drivers
(2) Evaluating and assessing the risks
(3) Mitigating risks within the supply chain
(4) Controlling risks by continuous process.

Implementing the above mentioned risk management process; we identify risks for next generation supply chains by using systems thinking. Applying the system of systems concept to specific supply chains, the supply chain network is represented in terms of nodes and connectors with their interrelations.

LITERATURE REVIEW

The application of System Dynamics modelling to supply chain management has its roots in Industrial Dynamics (Forrester, 1961). The supply chain flows often create important feedbacks among the partners of the chain, thus making System dynamics (SD) a well-suited modelling and analysis tool for next generation supply chain management. System dynamics consists of causal loop diagrams and stock and flow representations of the system. Causal loop diagrams play two important roles in SD. Firstly, they serve as preliminary sketches of causal hypotheses during model development and secondly, they can simplify the representation of a model (Georgiadis *et al.*, 2005). Stock equations define the accumulations within system and flow equations define the flows among the stocks as function of time. The typical purpose of a SD study is to understand how and why the dynamics of concern are generated and then search for policies to further improve the system performance. Here policies refer to the long-term, macro-level decision rules used by strategic level management (Vlachos *et al*, 2007).

Wikner *et al*. (1991) and Towill *et al*. (1992) have simulated different supply chain improvement strategies on demand amplification. Sterman (2000) presents two case studies where SD is used to model reverse logistics problems. Minegishi and Thiel (2000) use SD to understand the complex logistics behaviour of an integrated food industry. They present a generic model and then provide simulation results applied to the field of poultry production and processing. Pierreval (2007) provides a continuous simulation approach to study a French automotive company. Similarly, a SD model for capturing dynamic capacity planning for the remanufacturing process in a reverse supply chain is also developed (Vlachos, 2007). Oehmen *et al* (2009) have attempted a system oriented modelling approach to develop two supply chain models, to determine causes and effects of supply chain risks. From the literature it is observed that, in the supply chain risk management domain only a few attempts are made to understand the risks using a systems approach.

Supply chain risks are potential disruptions associated with inter-organisational logistics, caused by the inherent process or external sources that negatively impact the objectives of the logistics network (Juttner *et al*. 2003). The literature suggests four categories of risks: supply, demand, operational, and security risks (Christopher and Peck, 2004; Manuj and Mentzer, 2008) similarly, Ghoshal (1987) has classified risks as:

- *Macroeconomic risks* associated with significant economic shifts in wage rates, interest rates, exchange rates, and prices
- *Policy risks* associated with unexpected actions of national governments
- *Competitive risks* associated with uncertainty about competitor activities in foreign markets
- *Resource risks* associated with unanticipated differences in resource requirements in foreign markets.

Chopra and Sodhi (2004) classify supply risks as disruptions, delays, systems, forecast, intellectual property, procurement, receivables, inventory and capacity. There are several other classifications of supply chain risks in literature (Sinha *et al*, 2004; Finch, 2004; Kleindorfer and Saad, 2005; Tang, 2006; Tang and Tomlin, 2008). Next generation supply chain managers need to consider the degree of complexity in their various global supply chains, and then classify risks to define their mitigating strategies.

FACTORS AFFECTING NEXT GENERATION SUPPLY CHAINS

Information and Communication technology (ICT) and sustainability concerns may be the factors which will affect Next generation supply chains. Based on an extensive literature survey, the identified issues for next generation supply chain are represented below:

1. Environmental regulations
2. Information and communication technology
3. 3PL/4PL Logistics service
4. Global market
5. Customer expectations

6. Skills shortage

These issues will feed as input to System Dynamics modelling process to identify impact of these issues on risk assessment parameters within a supply chain. For assessment of risk the identified parameters are quality, delivery performance, cost, environmental initiatives, customer service and technical expertise.

SYSTEMS THINKING

The systems perspective adopted in this research is one of causal modelling. It focuses on understanding how the physical processes, information flows and managerial policies interact so as to create the dynamics of the variables of interest. Complex systems like supply chains are characterized by having large number of dimensions, nonlinear models, strong interactions, volatile parameters, time delays in dynamic structure (Jamshidi, 1983). Supply chain is similarly such a complex system consisting of a complex network of stakeholders and their dynamic interrelationships.

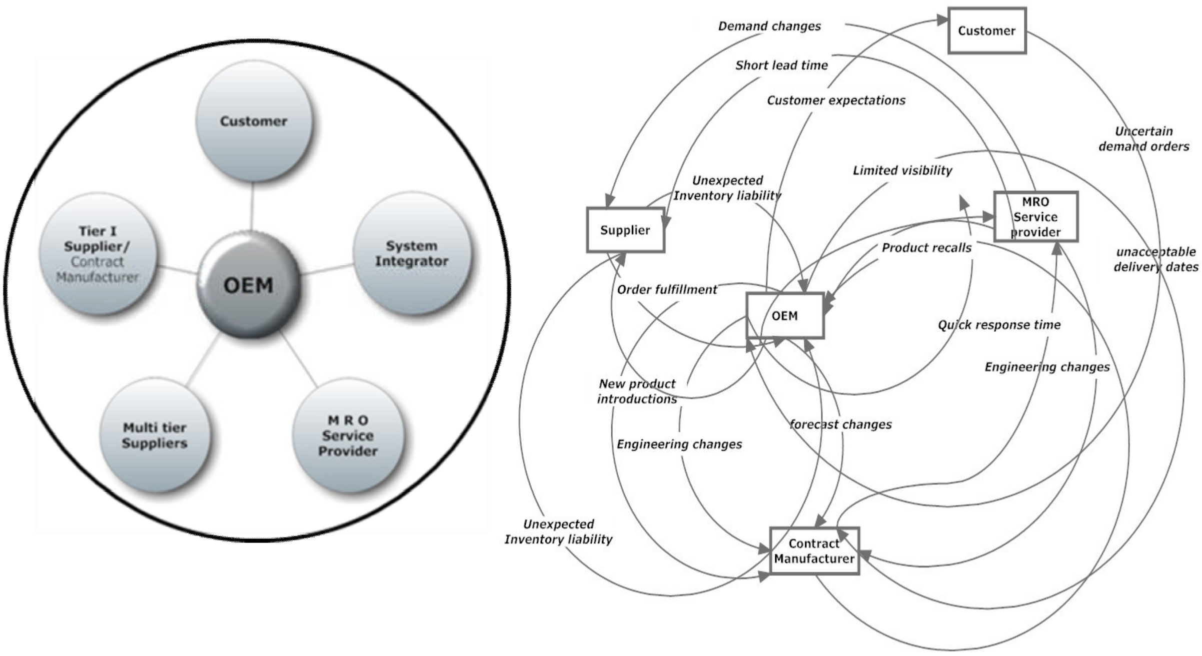


Figure 1 Typical supply chain network links from a systems perspective

For understanding a supply chain, we follow one defined by Kotov (1997) as large scale concurrent and distributed systems that are comprised of complex systems. A supply network/ chain is made up of various entities and nodes in the chain which are working together to achieve one single task, which is providing the final consumer/ customer the required product or service. The optimisation of one part of the chain doesn’t necessarily provide an optimised supply chain. The various entities have to be considered together from the perspectives of the interdependencies and the dependency on time to achieve the desired output and thus to make sure that the flow is not disrupted. Hence, the analogy of using a ‘Systems of Systems’ approach to understand supply chains. Figure 1 represents the system of systems approach to a typical aerospace supply chain network showing the hub and spoke structure of supply chain system and interrelating network links within supply chain entities. The figure presents the aerospace supply chains as a complex network of entities from the perspective of inter-related risks which can cause the flow to disrupt.

System dynamics is effective for the study of the important flows of products or components through the main production areas of the network, rather than a detailed study of the flow of each product through the set of resources available in the network. System Dynamics (SD) is commonly used for analysing complex, dynamic, uncertain

behaviour of supply chain network and to capture transient effects of flows (material, Information, Financial) in supply chain. SD provides valid description of real processes and integrates human with process and tools.
Based on our understanding, following are key characteristics of SD modelling:

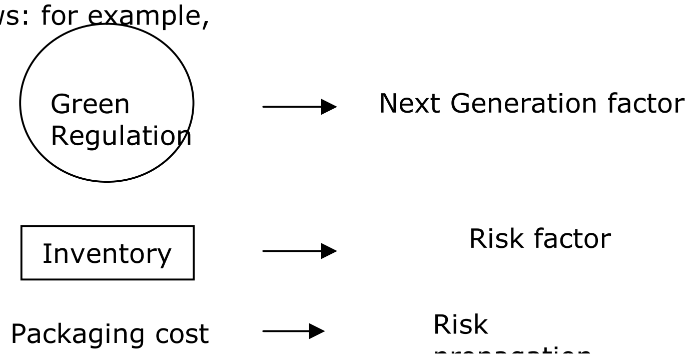
- Captures dynamic / stochastic behaviour
- Ability- Holistic view of system
- Integrates people, process & tools
- Feedback/Inter-relationships of system
- Compatibility-Mental model to computer model
- Early warning for potential risks
- Tool for structured development process

RESEARCH METHODOLOGY

The research was conducted in two phases. In the first phase an extensive literature review was conducted to understand the factors that would affect next generation supply chains. It was also necessary to understand how these factors would lead to risk propagation through the supply chain. The assumption was that all the identified factors will lead to some risk in the supply chain. To understand the interdependencies within these factors and the risk propagation on account of these factors it was decided to adopt a systems perspective. This perspective is based upon application of a causal loop diagram which considers the interdependencies between the factors affecting next-generation supply chains. The causal linkages between the variables are then highlighted with regards to the supply chain process and the nodes and causes of future risks are identified. Using the causal loop diagram, a risk framework is developed for next generation supply chains showing the impact of the risk. This is checked with some instances of risk propagation within the aerospace sector. It was decided to assess the effect of each individual factor taking into account the risks associated with the factor using a system dynamics simulation model. However, this was not successful and the next stage of the research will endeavour to create a simulation framework for simulating the risks associated with the risk factors.

NEXT GENERATION SUPPLY CHAIN RISK VARIABLES: CAUSAL RELATIONSHIP

Causal loop diagrams are the basis on which the SD model is built. They depict, graphically, the interactions and cause-and-effect relationships among the different system parameters (Lertpattarapong, 2002). During the model development, Causal loop diagrams serve as preliminary sketches of causal hypotheses and they can simplify the representation of a model. The structure of a dynamic system model contains stock (state) and flow (rate) variables. Stock variables are the accumulations (i.e. inventories), within the system, while flow variables represent the flows in the system (i.e. order rate). The model structure and the interrelationships among the variables are represented by causal loop diagrams. Figure 3 shows the causal relationship of identified next generation supply chain issues with risk assessment parameters. The representations are as follows: for example,



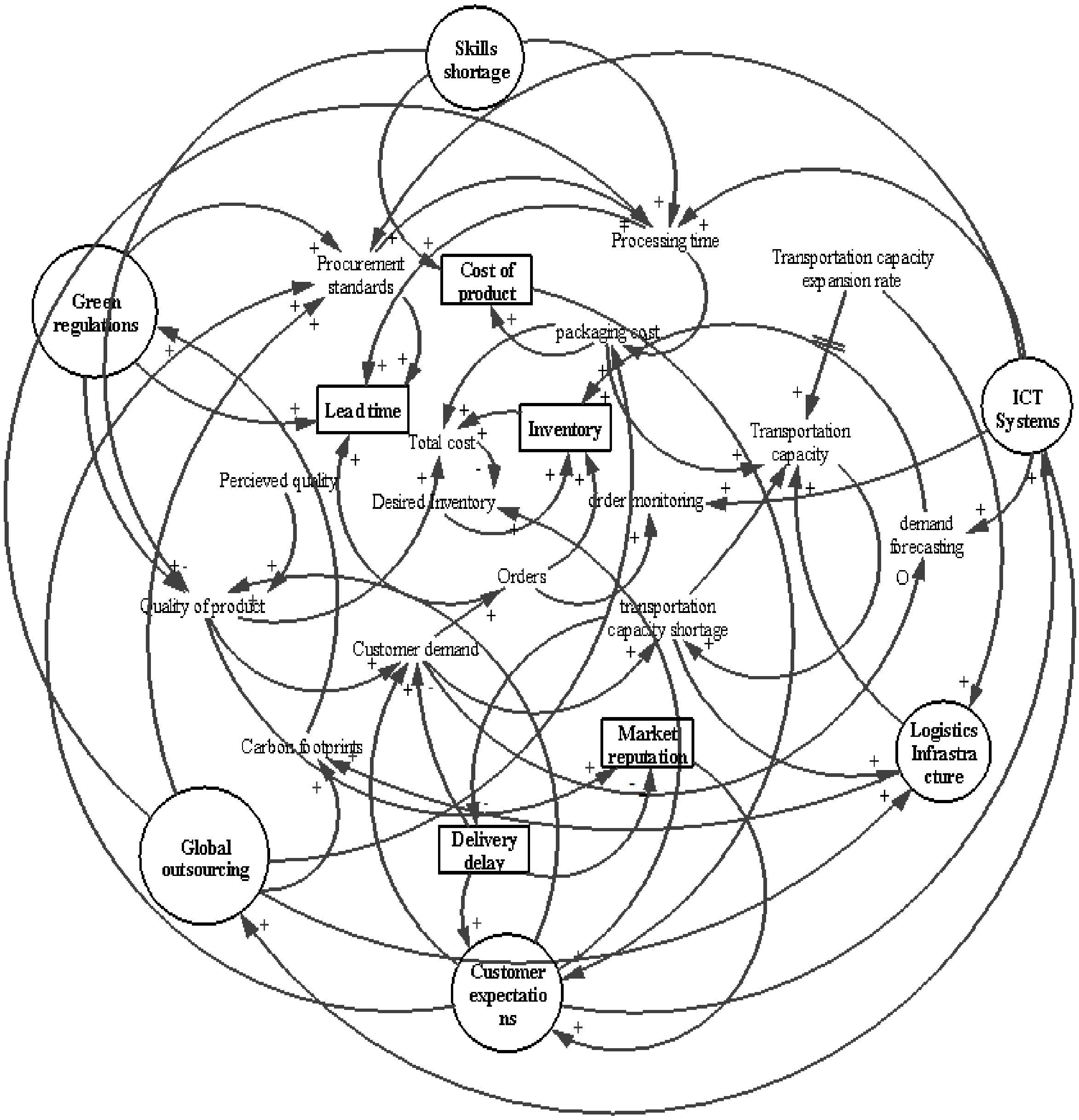


Figure 3: Causal loop diagram for next generation supply chain risks

With reference to the causal model, it can be inferred that this is not complete. Supply Chains are dynamic and as factors change, the risk parameters will modify and propagate. It is important to get a perspective to initially understand the system and then create the capability to dynamically modify it. From the causal loop diagram above, the risk propagation is derived in a risk framework as shown in figure 4.

Applying, the framework to some recent cases in the aerospace sector, it can be seen that the propagation of risk will lead to an increase in total costs, project delays and loss of reputation. This is shown in table 1. It seems fairly generic; however it is important to note that whatever the factors affecting next generation supply chains, the final impact will lead to issues of cost delays and reputation. This may modify sectorally, and the essence of further research would be to assign weights to each impact based on the sectoral perspective.

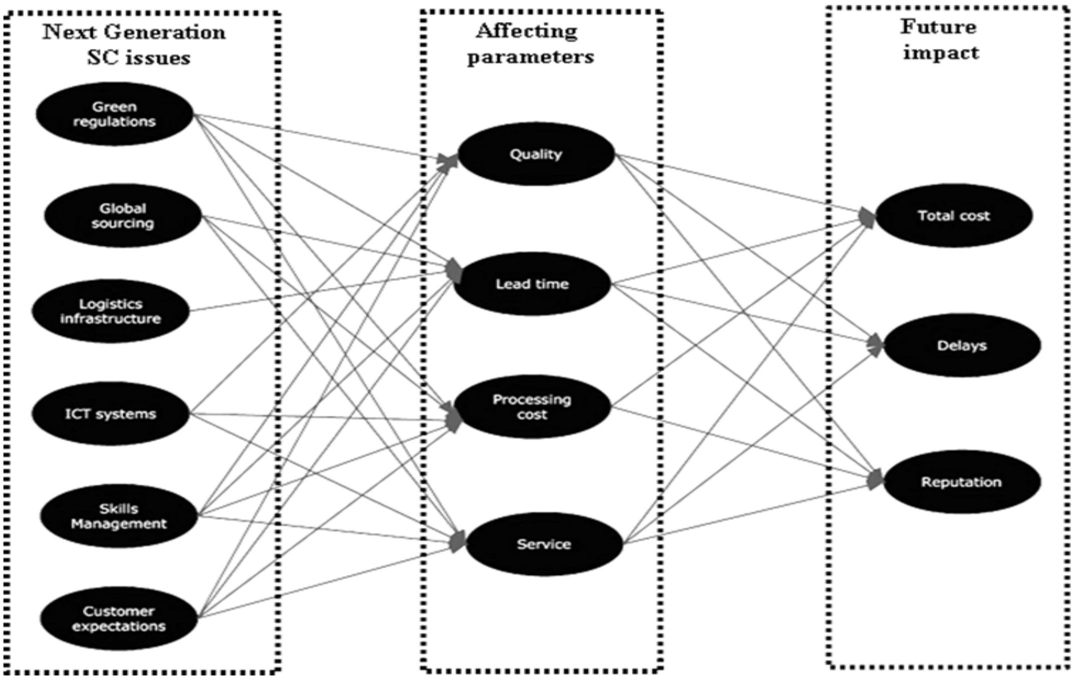


Figure 4: Next generation supply chain risk model

Industry	Supply Chain Disruption	Risk Impact
Airbus A380 (2005)	1) Distributed Integration dependencies among manufacturing sites and suppliers 2) Design configuration management problems (CATIA V4/V5)	1) Mismatch of electrical harness between designed and physically appeared routing on aircraft. 2) **Costly delays** for two years.
Boeing 787 (2006)	1) Failure of assemble to order manufacturing strategy 2) Failure by global supplier network to meet targets	1) Problems with spare parts led to **delays** up to 2 years. 2) **Financial loss** due to cancellation of orders. 3) **Reputation loss**
JSF F-35 Lockheed Martin (2010)	1) Development is being done concurrently with early production. 2) National shortage of professionals leading to longer flight test program.	1) JSF F-35 **delays** up to 2015 to US Air Force 2) Delays resulting in **heavy cost increases** to JSF program partners.

Table 1: some instances of supply chain risk propagation in the aerospace sector

CONCLUSION

The research approach for the paper is based upon application of systems engineering techniques to understand next generation supply chains and its use for managing various risks associated within the supply network. Factors affecting next generation supply chains are identified. A Causal loop diagram is depicted which considers the causal linkages between the factors and highlights with regards to the supply chain process, the nodes and causes of future risks. In this paper, the SD modelling approach identifies influential risk parameters for next generation supply chains which further would be mitigated through different risk management strategies as a future work towards developing a SCRM toolkit. The paper thus presents a new perspective towards using systems thinking to manage future supply chain risks. Simulating the complete model requires setting of dependence parameters/equations which is complex due to non-availability of data for a simulation model. An attempt was made to simulate the model using Vensim simulation software considering a part of the causal loop by taking few assumptions in developing parameters/equations. However, using simulation to study the problems involving supply chain disruptions has its problems and challenges. These challenges are most evident in four areas like, **Describing** and **modelling** the events triggering the supply chain disruption for example how to describe SCD and its associated critical traits and location of disruption and **identifying** and **setting** approximate policies and parameters (Zsidisin and Ritchie, 2008). Hence in this paper we have restricted the scope of research up to identifying risk factors that influence next generation supply chain and further investigation would be carried into possibilities of developing simulation model for risk assessment and designing mitigation strategies as a part of a SCRM toolkit.

REFERENCES

CHRISTOPHER, M., PECK, H. (2004), Building the resilient supply chain. *The International Journal of Logistics Management*, 15 (2), 1–13..

CHOPRA, S., SODHI, M.S. (2004), Managing risk to avoid supply chain breakdown, *MIT Sloan Management Review*, 46 (1), 53–61.

CRAIGHEAD C.W., BLACKHURST, J., RUNGTUSANATHAM, M.J., HANDFIELD, R.B. (2007), The severity of supply chain disruptions: Design characteristics and mitigation capabilities, *Decision sciences*, 38(1),131-156.

FINCH, P., *Supply* Chain Risk Management, *Supply Chain Management*, 9 (2), 183–196.

FORRESTER, W. JAY (1961*) Industrial Dynamics*. Cambridge, MA: MIT Press.

FORRESTER, J. W. AND SENGE, P. (1980), *Tests for Building Confidence in Systems Dynamics Models*. TIMS Studies in the Management Sciences, 14, 209-228.

GABLE G G. (1994), Integrating case study and survey research methods: an example in information systems*. European Journal of Information Systems*, 3(2), 112-126.

GEORGIADIS, P., VLACHOS, D., & IAKOVOU, E. (2005*),* A system dynamics modeling framework for the strategic supply chain management of food chains. *Journal of Food Engineering,* 70(3), 351-364.

GHOSHAL, S. (1987), Global strategy: an organizing framework, *Strategic Management Journal*, 8 (5), 425-440.

JAMSHIDI, M. (1983), *Large-scale systems: Modeling and control*. North-Holland, New York.

JUTTNER, U., PECK, H., & CHRISTOPHER, M. (2003), Supply chain risk management: Outlining an Agenda for future research*. International Journal of Logistics: Research and Applications*, 6(4), 197-210.

KLEINDORFER, P.R., SAAD, G.H. (2005), Managing disruption risks in supply chains*. Production and Operations Management*, 14 (1), 53–68.

KOTOV. V. (1997), *Systems of Systems as Communicating Structures, Hewlett Packard Computer Systems Laboratory* ,Paper HPL-97-124, pp. 1-15.

LERTPATTARAPONG C. (2002), *Applying system dynamics approach to the supply chain management problem*. Master thesis. System Design and Management Program. Sloan School of Management. Massachusetts Institute of Technology

MINEGISHI S, THIEL D. (2008), System dynamics modeling and simulation of a particular food supply chain. *Simulation Practice and Theory*, (8), 321–339.

OEHMEN. J, ZIEGENBEIN. A, ALARD. R,SCHONSLEBEN, P.(2009), System-oriented supply chain risk management, *Production Planning & Control* Vol. 20, No. 4, June 2009, 343–361.

PIERREVAL. H, BRUNIAUX, CAUX (2007), A continuous simulation approach for supply chains in the automotive industry*. Simulation Modelling Practice and Theory*, 15 (2), 185-198.

RICHARDSON, G. P., AND A. L. PUGH III.(1981), *Introduction to System Dynamics Modelling with DYNAMO*, MIT Cambridge, MA, Productivity Press.

SINHA, P.R., WHITMAN, L.E., MALZAHN, D.(2004), Methodology to mitigate supplier risk in an aerospace supply chain*. Supply Chain Management*, 9 (2), 154–168.

STEFANOVIC, D., STEFANOVIC, N., & RADENKOVIC, B. (2009), Supply network modelling and simulation methodology*. Simulation Modelling Practice and Theory*, 17(4), 743-766.

STERMAN JD. (2000), *Business dynamics: systems thinking and modeling for a complex world*. NewYork: McGraw-Hill.

TANG, C. (2006), *Perspectives* in Supply Chain Risk Management*. International Journal of Production economics*, 103 (2006), 451-488.

TANG, C.S., TOMLIN, B. (2008), The power of flexibility form mitigating supply chain risks*. International Journal of Production Economics*, 116(1), 12–27.

TOWILL D R, NAIM M M, WIKNER J. (1992), Industrial dynamics simulation models in the design of supply chains*. International Journal of Physical Distribution Logistics Management*; 22(5), 3–13.

VLACHOS, D., GEORGIADIS,P., IAKOVOU,E.,A. (2007), System dynamics model for dynamic capacity planning of remanufacturing in closed-loop supply chains. *Computers and operations research,* 34, 367–394.

WIKNER J, TOWILL DR, NAIM M. (1991), Smoothing supply chain dynamics. *International Journal of Production Economics*, 22(3),231–48

WILLIAMS, D. (2000), *Dynamic Synthesis: A Theoretical Framework for Research in Requirements Engineering Process Management*. Operational Research Society,.

YIN R K (1984), *Case Study Research: Design and Methods*. Sage, Beverly Hills, California.

ZSIDISIN. GEORGE A., RITCHIE B. (2008), *Supply Chain Risk: A Handbook of Assessment, Management, and Performance*, Edited book, 103-120.

COMPLEXITY IN VOLATILE SUPPLY NETWORKS

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ABSTRACT
Due to dynamic environmental conditions economic value networks are showing a rising complexity. This leads to limited amenability for enterprise planning and steering. A critical success factor for a company's competitiveness therefore is the identification of the most relevant network segments from a complexity perspective. A corresponding method must be easy to apply and has to provide fast execution in order to enable permanent application. The primary purpose of this paper is to identify relevant influence factors which determine value network complexity. In a second step these findings are integrated into a broader framework. The results are based on system theory and on intensive literature research.

INTRODUCTION: COMPLEXITY AS THE BASIC PRINCIPLE OF BUSINESS SETTINGS
Our considerations start at the roots, with the nonentity. We assume that at the beginning of the world nothing existed but ylem. Ylem is neither differentiated nor formed, doesn't have a structure and consists of an indefinite number of elements and relations. In addition to this, all imaginable elements can lead to an imaginable amount of relationships between these elements (Krieger, 1998). Subsequently in this state the degree of complexity is indefinite – and therefore unmanageable. In order to achieve the differentiation that constitutes the existence of a system, the unformed elements have to be abstracted and aligned. By applying this idea on social systems, in our case on enterprises and value networks, the consequence is: creating a system means to differentiate certain parts of the indefinite nonentity. From an economic perspective the necessary differentiation occurs as a functional division of labor. In this regard a company will shape its elements – e.g. personnel, technical or material resources – in an adequate way and set up a working structure between them (hierarchy, process design, and communication). These interrelations enable certain operations and processes based on control (Krieger, 1998), e.g. a company sufficiently fulfills the customer needs through a specified sequence of activities. A value network consists of enterprises with mutual material, information and money flows. In addition to the internal task of defining the enterprise organization, a firm has to establish supplier and customer relations. This again means differentiation: With whom should I work (amount of contracted parties)? Which of those partners should get management attention? Which of them, relevant for the management, should be integrated into my flows? Which of those, not directly attached (e.g. my supplier's supplier), should still be in the focus of my management activities? Following these questions, a careful selection of elements and relations has to be done according to a company's environmental conditions. The result of this differentiation is a well-working system definition of the relevant (=managed) supply net. As shown so far, differentiation (that means selection decisions) is necessary and constitutes the existence of a system. Furthermore differentiation leads to a lower, now definite degree of complexity, compared to the nonentity state. The origin of all attempts to create systems, as well social systems, therefore is to reduce complexity (Luhmann, 1984). Complexity can be assumed as the origin of a systems' synthesis (Krieger, 1998). In the case of value networks and supply chain management (SCM) this means: The appropriate definition of the system borders from a complexity perspective is a critical success factor that enables controllability. Herein, a company has to fulfill Ashby's law of requisite variety (Ashby and Bauer, 1985): Complexity has to be reduced far enough to achieve steerability, but not reduced down to market incompatibility (because of not being differentiated enough towards the market demand).

For the case of SCM an additional difficulty arises: There is no such thing as an objectively proven value network border, shared by every network participant. In contrast to that each company (to be precise each decision maker in each company) defines an own idea, who is part of the system, who is not. Subsequently there are as many mental system constructs as there are surveyors, each having a different system definition. At best definitions might be similar. Still the following question remains essential for a decision maker: How could I define my supply network borders appropriately in order to reduce complexity to a manageable degree and to come to advantageous decisions for my company's business? This paper intends to develop a model to differentiate a company's supply network borders on the basis of complexity parameters. Complexity is seen as a prototypical approach that shall be extended upon further aspects, e.g. uncertainty, risk or flexibility in future research works. Since the abstract term 'complexity' has to be further operationalised, at first parameters are identified that are capable of substantiating complexity more concretely. Secondly a framework is proposed which shows how the derived criteria could be processed in the course of decision processes.

BUT: IS A SUPPLY NETWORK A SYSTEM? A SYSTEMS THEORY VIEW

As mentioned above, first of all the question has to be answered, whether we may assume a supply network as a dynamic, open, complex socio-technical system at all, while system theory demands it to be a mental construct that is not even shared equally by all participants ('participant' being a decision maker in this network and being used as the substantiation for the term 'surveyor'). The similarity degree between supply network definitions may vary from 0 to 100 %. Before analyzing the relevance of this similarity issue, a further differentiation is important: Even a single decision maker may (validly) apply different system borders, depending on the upcoming decision. For example the question, who is a relevant supplier, may be answered differently for different product lines of a company. This changes the initial question: What the company or a decider calls a 'relevant supply network system', is basically a simplified model for decision support purposes that serves a group of deciders regarding a certain class of decisions, e.g. customer or supplier management decisions. The model purpose is to reduce complexity to a manageable amount that still allows advantageous decisions. Therefore, as long as the model doesn't neglect important influences, the similarity issue is of minor relevance. For the supplier example given above, one product line may ignore supplier decisions of the other product line as long as there are no dependencies between them. As soon as major dependencies occur, it must be analyzed, whether the sum of both individual decisions will lead to an optimum for the company as a whole.

The conclusion is that a value network system may be seen from an unknown amount of surveyors differently, not necessarily known or shared by everybody. As long as the mental system construct of a certain decider is appropriate to support a certain decision, there is no argument against that, no matter whether this constitutes 'a' unique system or not. The critical requirement to be fulfilled rather is the complexity reduction. A mental system construct excludes certain elements or relations. Still it assumes the whole construct to behave in the estimated way. This works fine, whenever the whole equals the sum of its parts. Unfortunately, in contrast to that reductionistic view, a non-linear system will show emergent behavior. In this case a linear model might cause misleading decisions. In principle there are three ways to cope with that problem: The first, a complete system analysis is not possible due to the high complexity. The second, an analysis towards which unforeseen factors a system will respond could be done to a certain amount, especially in combination with the third: Instead of an unrealistic belief in long-term planning stability, a company should accept the fact that a supply network will present unforeseen developments. Therefore, enterprise performance should be aligned towards a new set of principles that are more abstract than typical business targets: Adaptability, learning ability and system stability. Off course those principles are to be reached through more operational objectives, but those might be allowed to change according to actual requirements – e.g. from margin maximization during one economic period towards liquidity optimization during another. Coming back to system theory, this allows for higher complexity: Instead of an exogenously planned order that necessarily will neglect important influences, a more self-organized, more endogenous order could be the management answer to growing complexity if reductionistic complexity decrease won't work anymore.

A FIRST METHODOLOGICAL STEP: LITERATURE REVIEW REGARDING COMPLEXITY

The systematic review of articles on business logistics, transportation and SCM and the selection of these articles is presented in this chapter. The journals were selected from EBSCOHost, Emerald Insight and Science Direct. According to the analysis of Menachof et al. (2009) the 12 top-ranked journals in logistics and SCM [Journal of Business Logistics, International Journal of Physical Distribution and Logistics Management, International Journal of Logistics Management, Journal of Operations Management, Supply Chain Management Review, Transportation Journal, Harvard Business Review, Management Science, Transportation Research: Part E, Supply Chain Management: An International Journal, International Journal of Operations and Production Management, International Journal of Logistics: Research and Applications] have been reviewed from the year 2000 up to now. Menachof et al. (2009) developed a ranking on the basis of a survey focusing on the quality of peer reviewed periodicals for faculty research use. The papers were systematically selected and classified for identification and analysis. As search keywords we applied 'complexity' in combination with 'supply chain' and 'network'. In addition to this also overlaps between the term pairs 'complexity & supply chain' and 'complexity & network' were checked. According to a quick scan through the abstracts 107 papers were selected as the fundamental basis for the analysis. Among them 17 papers [marked with * within the references] explicitly treat the issue 'complexity' and focus on complexity-determining and/or complexity-influencing parameters.

STEP TWO: THE PRACTICAL SIDE - A FRAMEWORK FOR SYSTEM DIFFERENTIATION

The practical consequence of the aforementioned arguments is that a company needs methodological support during three different steps of complexity reduction in the course of management decision processes:

(1) there has to be a <u>valid set of criteria</u> to be applied for the selection of whom to include into the relevant supply network and whom to exclude. In theory one can find several categories for that purpose, e.g. complexity, risk, flexibility innovation etc. The best case is to analyze them all. In practice this is not possible in a single initiative. Therefore complexity as the origin of system existence has been chosen as a starting point. In addition to theoretical contributions there are also practical approaches. Especially supplier relationship management (SRM), customer relationship management (CRM) or capacity evaluation methods are currently using valid criteria (partially also theory-based) sets in order to evaluate possible action needs and the impacts to be expected from management initiatives.

(2) the identified criteria have to be processed. This demands appropriate <u>models and algorithms</u> in order to derive conclusions for an upcoming decision. The practical approaches like SRM or CRM are usually using simple grids or scoring models for that purpose.

(3) a decision maker will try to achieve a valid estimation on whether (or whether not and to what extend) a certain measure that has been recommended by applying the criteria (1) on the appropriate procedure (2) will <u>improve the enterprise performance</u>: Once the adequate criteria are found to feed the appropriate model it should be possible to evaluate the benefits. An easy and commonly accepted basis for this evaluation is e.g. a ROI or EBIT calculation. Although 'enterprise performance' is more than financial success, this could be a first approach, to be individually extended on demand in a certain case. Fig. 1 shows how to assemble those considerations into a methodological framework:

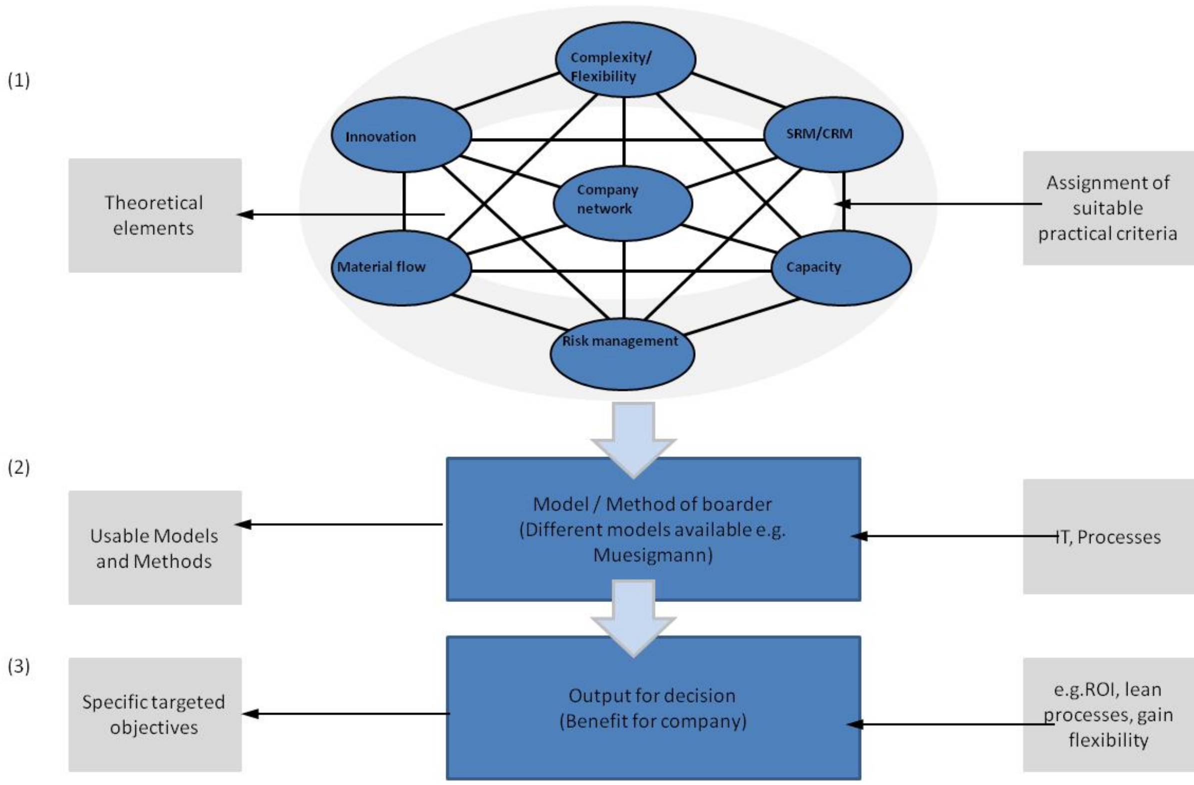

Figure 1: framework for system border definition within a supply network

In this context complexity is regarded as basic SCM principle. Further, the increasing complexity of supply networks makes the identification of the relevant partners impossible. For both reasons complexity has been investigated first. Flexibility and risk are recommended as the next issues for future research (subsequent to complexity). This is due to the importance of both concepts for the above mentioned leading principles of adaptability, learning ability and system stability. Here, 'flexible' is defined as "agile (free to move), adaptable, adjustable or even elastic" (Horstmann, 2007). Flexibility is important to ensure longtime performance and contributes to strategic enterprise profit (Günthner, 2007), whereas concrete objectives (e.g. EBIT, liquidity) may vary during business phases. Although risk (defined as the probability of an incident that leads to the inability to meet customer demand or causes threats to customer life and safety, Zsidisin (2003)) has been studied in numerous business settings, especially in combination with uncertainty, there is little understanding of what risk means in a SCM context (Zsidisin, 2003). In the following section our results for 'complexity' are shown in detail and could be applied on 'flexibility' and 'risk' analogously.

Complexity is not restricted to directly contracted partners. Therefore, there are two challenges: To find a way to determine complexity and to apply a model with an extended (not only dyadic) focus. Many authors developed approaches to determine complexity:

- from an information theoretic perspective (Shannon and Weaver, 1963,Frizelle and Woodcock, 1995, Sivadasan et al., 2006)
- from systems theory (Bliss, 2000)
- evolutionary approaches describing interactions between organisms and environment (Meszena et al., 2001; Kauffman, 1993)
- the research field of complex adaptive systems (Choi and Krause, 2006, Choi, Dooley and Rungtusanatham, 2001, Holland, 1992)
-

Most of them focus on internal complexity with a static character. None of the systems theory approaches have been adequately transferred to the domain of supply networks

(Dekkers et al., 2005). Hence, the challenge for complexity research in supply networks is the identification of adequate methods for system representation, the analysis of interdependence between core elements, and the specification of complexity parameters, accounting for the complexity emerging from the environment (Schuh, Sauer and Döring, 2006). Therefore, in a first step a method for system representation with an extended focus has to be identified within existing approaches for SRM. Most available tools, methods and IT-solutions to identify the relevant supply chain (SC) partners focus on dyadic relations with suppliers. Thus, their usability in the context of supply networks is limited due to the existing interdependencies in upstream layers and the resulting implications and risks (Angeli, 2002). An exception is the supplier network management reference model developed by Müssigmann (2007) which enables the implementation of individual criteria and an evaluation of the supplier network from an extended (not just dyadic) view. The authors are confident that it can be further enhanced in order to enable the identification of the most important SC partners from a complexity perspective (and in a next step also from other point of views).

Müssigmann (2007) describes several steps to identify the most important SC partners within the supply network. Each node and edge in the examined network segment is represented through complexity parameters which are bundled in an evaluation vector (step 1 in Fig. 2). The vector consists of complexity determining and influencing parameters that are identified in the next section of this paper. Based on the defined evaluation vector for each node and these vectors are consolidated in one evaluation vector for the entire value network or the network segment examined (step 2 in Fig. 2). As each criteria can be from different importance in different environmental conditions and from a singles company perspective, there is a weighting vector (step 3 in Fig. 2). Finally, a position index for each network segment can be created by multiplication of each criteria of the evaluation vector with the corresponding element of the weighting vector. The result is the identification of the relevant network segments, herewith identifying the most important SC partners.

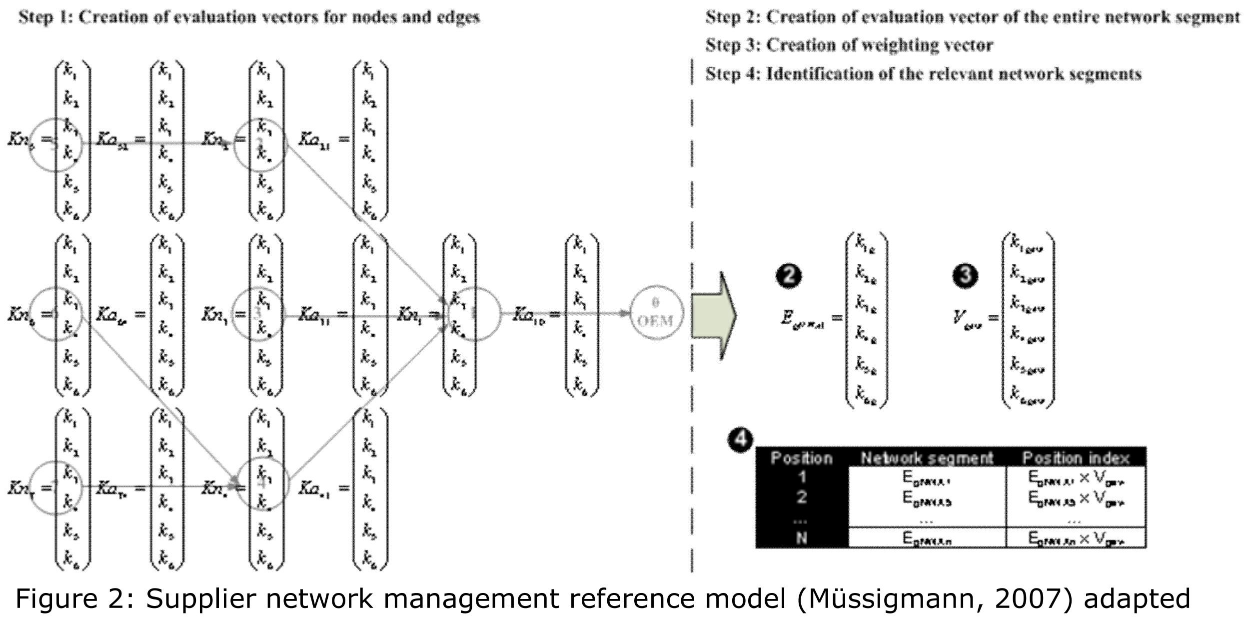

Figure 2: Supplier network management reference model (Müssigmann, 2007) adapted (Gerschberger, Söser and Staberhofer, 2009)

FINDINGS

The literature review shows that more than 70 % of the authors identified the number of elements (of the value network) as a central parameter determining the complexity - followed by uncertainty. Within the term 'uncertainty' key variables for nodes [e.g. demand volatility, unpredictability of competitors, product obsolescence rate; (Vickery et al., 2004)] and edges [e.g. late deliveries; (Milgate, 2001)] are included. Therefore, uncertainty is a complexity parameter for nodes and for edges. According to the 12 top-ranked logistics and SCM journals, two more parameters reached a satisfying number of mentions: the number of interrelations and variety. Especially 'variety' needs further clarification (how to measure and manage variety can be seen as a separate research discipline, e.g. Blecker and Abdelkafi, 2006, Blecker et al., 2003, Westphal and Kummer, 2001, Heina, 1999).

	Structural complexity-determining parameters				Complexity-influencing parameters		
Author	Number of elements	Heterogeneity of elements (autonomy)	Number of interrelations	Heterogeneity of interrelations (geographical components)	Uncertainty	Dynamic	Customer-driven product variety
(Milgate, 2001)							
(Prater, Biehl and Smith, 2001)							
(Choi and Hong, 2002)							
(Sivadasan et al., 2002)							
(Guide, Jayaraman and Linton, 2003)							
(Oke, 2003)							
(Vickery et al., 2004)							
(Sanchez and Perez, 2005)							
(Choi and Krause, 2006)							
(Stonebraker and Liao, 2006)							
(Meepetchdee and Shah, 2007)							
(Jonsson, Kjellsdotter and Rudberg, 2007)							
(Masson et al., 2007)							
(Christensen, Germain and Birou, 2007)							
(Kinra and Kotzab, 2008)							
(Wycisk, McKelvey and Hulsmann, 2008)							
(Bozarth et al., 2009)							
Total	12	2	6	4	9	2	6

Table 1: Parameters of Complexity (Gerschberger et al., 2010)

The idea of this paper was to highlight the parameters of complexity within a value network. In a next step the interdependencies between the identified parameters of complexity have to be quantified. Above all the question how to aggregate the single parameters of complexity has not been initialized and investigated in detail up to now.

CONCLUSION

Differentiation and complexity have been the starting point to setup the framework in fig. 1. Flexibility and risk are proposed as further objects for theoretical investigation. The findings have to be combined with practical approaches from SRM or CRM and step by step assembled into a holistic criteria set (1) within future research projects. Table 1 exemplarily has done that for the case of 'complexity'. The Müssigmann model is a promising approach that can adequately process such criteria in a network context (2). The model will have to be developed further, eventually also supplemented by other models. The necessary link to enterprise performance currently will most probably be represented through financial figures (3) – e.g. an estimation of the ROI-impact of a measure. This also has to be extended in future contributions. Altogether our current state shows that the framework works well with complexity and allows promising perspectives in all categories (1) to (3). Additional future research needs can be seen in the broad validation of the results achieved so far within a respectable number of companies and practical case studies.

Not yet fully answered is the management approach towards unexpected, emergent behavior of complex systems. Our proposed answer, next to the framework and criteria set is the enforcement of more abstract targets, especially adaptability, learning ability and system stability and the acceptance of an incremental management approach that – close to cybernetic systems - incrementally responds to changes – if necessary even with changed target indicators (not to be mistaken for an unfavorable 'moving target' approach). Future research is needed to further specify that concept.

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REFERENCES

Angeli, Ralf. "Aufbau und Koordination dynamischer Unternehmensnetzwerke." 2002.

Ashby, William R., and Bauer, Wilhelm L. *Einführung in die Kybernetik*. 2nd ed. Frankfurt am Main: Suhrkamp, 1985.

Blecker, Thorsten, and Abdelkafi, Nizar. *Complexity management in supply chains: Concepts, tools and methods*. Berlin: E. Schmidt, 2006.

Blecker, Thorsten, Abdelkafi, Nizar, Kaluza, Bernd, and Friedrich, Gerhard. "Key Metrics System for Variety Steering in Mass Customization." Proceedings of the 2nd Interdisciplinary World Congress on Mass Customization and Personalization - MCPC'03, Munich, October 6-8, 2003.

Bliss, Christoph. *Management von Komplexität: Ein integrierter, systemtheoretischer Ansatz zur Komplexitätsreduktion*. Univ., Diss.--Münster (Westfalen), 1999. Wiesbaden: Gabler, 2000.

*Bozarth, Cecil C., Warsing, Donald P., Flynn, Barbara B., and Flynn, E. James. "The impact of supply chain complexity on manufacturing plant performance." *Journal of Operations Management* 27, no. 1 (2009): 78–93.

Choi, Thomas Y., Dooley, Kevin J., and Rungtusanatham, Manus. "Supply networks and complex adaptive systems: control versus emergence." *Journal of Operations Management* 19, no. 3 (2001): 351–366.

*Choi, Thomas Y., and Hong, Yunsook. "Unveiling the structure of supply networks: case studies in Honda, Acura, and DaimlerChrysler." *Journal of Operations Management* 20, no. 5 (2002): 469–493.

*Choi, Thomas Y., and Krause, Daniel R. "The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation." *Journal of Operations Management* 24, no. 5 (2006): 637–652.

*Christensen, William J., Germain, Richard N., and Birou, Laura. "Variance vs average: supply chain lead-time as a predictor of financial performance." *Supply Chain Management: An International Journal* 12, no. 5 (2007): 349–357.

Dekkers, Rob, Sauer, A., Schönung, M., and Schuh, Günther. "Complexity based approach for collaborative enterprise networks." CARV 2005 - 1st International Conference on Changeable, Agile, Reconfigurable and Virtual Production, München, 22-23.09. 2005.
Frizelle, Gerry, and Woodcock, E. "Measuring complexity as an aid to developing operational strategy." *International Journal of Operations & Production Management* 15, no. 5 (1995): 26–39.
Gerschberger, Markus, Engelhardt-Nowitzki, Corinna, Nietsch, Inger, and Staberhofer, Franz. "Analyzing value networks: Identification of the parameters of complexity within a volatile value network." 17th International Annual EurOMA Conference, Porto, 06.-09. 2010.
Gerschberger, Markus, Söser, Christian, and Staberhofer, Franz. "Complexity in global value networks: introduction of a promising model to determine complexity." Proceedings of the 14th International Manufacturing Symposium; Cambridge, 26.-25.09. 2009.
*Guide, V. D. R., Jayaraman, Vaidy, and Linton, Jonathan D. "Building contingency planning for closed-loop supply chains with product recovery." *Journal of Operations Management* 21, no. 3 (2003): 259–279.
Günthner, Willibald A. *Neue Wege in der Automobillogistik: Die Vision der Supra-Adaptivität ; mit 14 Tabellen*. 1st ed. Berlin: Springer, 2007.
Heina, Jürgen. *Variantenmanagement: Kosten-Nutzen-Bewertung zur Optimierung der Variantenvielfalt*. Techn. Univ., Diss. u.d.T.: Variantenmanagement--Cottbus, 1999, integrierte Kosten-Nutzen-Bewertung zur Optimierung der Variantenvielfalt. Wiesbaden: Dt. Univ.-Verl. [u.a.], 1999.
Holland, J. H. "Complex adaptive systems." *Daedalus (*1992): 17–30.
Horstmann, Jörg. *Operationalisierung und Unternehmensflexibilität: Entwicklung einer umwelt- und unternehmensbezogenen Flexibilitätsanalyse*. Univ. Fachbereich Wirtschaftswissenschaften, Diss. u. d. T.--Gießen, 2006, Horstmann, Jörg Conrad : Operationalisierung der Unternehmensflexibilität - ganzheitliche Konzeption zur umwelt- und unternehmensbezogenen Flexibilitätsanalyse. 1st ed. Wiesbaden: Dt. Univ.-Verl., 2007.
*Jonsson, Patrik, Kjellsdotter, Linea, and Rudberg, Martin. "Applying advanced planning systems for supply chain planning: three case studies." *International Journal of Physical Distribution & Logistics Management* 37, no. 10 (2007): 816–834.
Kauffman, Stuart A. *The origins of order: Self-organization and selection in evolution*. New York: Oxford Univ. Press, 1993.
*Kinra, Aseem, and Kotzab, Herbert. "UNDERSTANDING AND MEASURING MACRO-INSTITUTIONAL COMPLEXITY OF LOGISTICS SYSTEMS ENVIRONMENT." *Journal of Business Logistics* 29, no. 1 (2008): 327–346.
Krieger, David J. *Einführung in die allgemeine Systemtheorie*. 2nd ed. München: Fink, 1998.
Luhmann, Niklas. *Soziale Systeme: Grundriß einer allgemeinen Theorie*. Frankfurt am Main: Suhrkamp, 1984.
*Masson, Ron, Iosif, Laura, MacKerron, Grant, and Fernie, June. "Managing complexity in agile global fashion industry supply chains." *The International Journal of Logistics Management* 18, no. 2 (2007): 238–254.
*Meepetchdee, Yongyut, and Shah, Nilay. "Logistical network design with robustness and complexity considerations." *International Journal of Physical Distribution & Logistics Management* 37, no. 3 (2007): 201–222.
Menachof, David A., Gibson, Brian J., Hanna, Joe B., and Whiteing, Anthony E. "An analysis of the value of supply chain management periodicals." *International Journal of Physical Distribution & Logistics Management* 39, no. 2 (2009): 145–165.
Meszena, G., Kisidi, E., Dieckmann, U., Geritz, S. A. H., and Metz, J. A. J. "Evolutionary Optimization Models and Matrix Games in the Unified Perspective of Adaptive Dynamics." *Selection* 2, no. 1 (2001): 193–210.
*Milgate, Michael. "Supply chain complexity and delivery performance: an international exploratory study." *Supply Chain Management: An International Journal* 6, no. 3 (2001): 106–118.

Müssigmann, Nikolaus. *Strategische Liefernetze: Evaluierung, Auswahl, kritische Knoten*. Univ., Diss.--Augsburg, 2006. 1st ed. Wiesbaden: Dt. Univ.-Verl., 2007.
*Oke, Adegoke. "Drivers of volume flexibility requirements in manufacturing plants." *International Journal of Operations & Production Management* 23, no. 12 (2003): 1497–1513.
*Prater, Edmund, Biehl, Markus, and Smith, Michael Alan. "International supply chain agility - Tradeoffs between flexibility and uncertainty." *International Journal of Operations & Production Management* 21, 5/6 (2001): 823–839.
*Sanchez, Angel M., and Perez, Manuela Perez. "Supply chain flexibility and firm performance: A conceptual model and empirical study in the automotive industry." *International Journal of Operations & Production Management* 25, no. 7 (2005): 681–700.
Schuh, Günther, Sauer, Alexander, and Döring, Sebastian. "Modeling Collaborations as Complex Systems." ISC 2006, Palermo, 5.-7.06. 2006.
Shannon, Claude E., and Weaver, Warren. *The mathematical theory of communication*. Urbana: Univ. of Illinois Pr., 1963.
Sivadasan, S., Efstathiou, J., Calinescu, A., and Huaccho Huatuco, L. "Advances on measuring the operational complexity of supplier–customer systems." *European Journal of Operational Research* 171, no. 1 (2006): 208–226.
*Sivadasan, S., Efstathiou, J., Frizelle, G., Shirazi, R., and Calinescu, A. "An information-theoretic methodology for measuring the operational complexity of supplier-customer systems." *International Journal of Operations & Production Management* 22, no. 1 (2002): 80–102.
*Stonebraker, Peter W., and Liao, Jianwen. "Supply chain integration: exploring product and environmental contingencies." *Supply Chain Management: An International Journal* 11, no. 1 (2006): 34–43.
*Vickery, Shawnee K., Droge, Cornelia, Stank, Theodore P., Goldsby, Thomas J., and Markland, Robert E. "The Performance Implications of Media Richness in a Business-to-Business Service Environment: Direct Versus Indirect Effects." *Management Science* 50, no. 8 (2004): 1106–1119.
Westphal, Jan R., and Kummer, Sebastian. *Komplexitätsmanagement in der Produktionslogistik: Ein Ansatz zur flussorientierten Gestaltung und Lenkung heterogener Produktionssysteme*. Techn. Univ., Diss.--Dresden, 2001. 1st ed. Wiesbaden: Dt. Univ.-Verl., 2001.
*Wycisk, Christine, McKelvey, Bill, and Hulsmann, Michael. "Smart parts supply networks as complex adaptive systems: analysis and implications." *International Journal of Physical Distribution & Logistics Management* 38, no. 2 (2008): 108–125.
Zsidisin, George A. "A grounded definition of supply risk." *Journal of Purchasing & Supply Management* 9, 5/6 (2003): 217.

A FRAMEWORK FOR DEVELOPING FLEXIBILITY IN ENGINEER-TO-ORDER SUPPLY CHAINS

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ABSTRACT
The engineer-to-order (ETO) supply chain is characterised by high levels of customisation and is usually managed in a project environment. This paper presents and evaluates a four-step framework for achieving appropriate flexibilities to mitigate the uncertainties experienced in such supply chains. The framework was developed through relevant literature streams and through a case research phase; it was then assessed via an evaluation phase. The resulting framework provides a practical route map for organisations to follow. The principal academic contribution is the synthesis of concepts related to supply chain structures, supply chain uncertainty, pipeline management and supply chain flexibility, making the important contribution of consolidating and establishing relationships between fields and concepts.

INTRODUCTION
The ETO supply chain includes sectors such as construction, capital goods and shipbuilding, and is characterised by high levels of customisation for each product and is typically managed in a project environment, with the decoupling point at the design stage (Gosling and Naim, 2009b). A 'no-one-size-fits-all' approach to supply chain management argues that different types of supply chains have different uncertainty profiles, and strategy must be matched with these profiles (Fisher, 1997, Aitken et al., 2005). There is little academic literature addressing the particular uncertainties relating to the ETO supply chain, or any investigation into how these uncertainties may be managed. While a few notable studies can be highlighted (Amaro et al., 1999, Hicks et al., 2000), there is no consensus on definitions, models and strategies that are suitable for this particular type of supply chain. Bringing these themes together, *the primary aim of this paper is to develop a framework for achieving appropriate flexibilities to mitigate the uncertainties in ETO supply chains.* This primary aim is broken down into 4 research questions, which are presented in the research method section.

LITERATURE REVIEW
This paper seeks to build on, and integrate, four literature streams. A summary of the streams, along with key authors, is shown in table 1. These streams provide the basis for a 4-step framework, which is described later in the paper.

Stream 1 - Supply Chain Structures
A range of frameworks for supply chain structures have been proposed to illustrate the diverse range of supply chain operations. These frameworks propose to make sense of the diverse range of supply chain operations by showing how different parts of the supply chain interact with customer orders. Based on Hoekstra and Romme (1992), Naylor et al. (1999), Yang and Burns (2003), Olhagar (2003) and Lampel and Mintzberg (1996) six different supply chain structures can be defined: engineer-to-order (ETO), buy-to-order (BTO), make-to-order (MTO), assemble-to-order (ATO), make-to-stock (MTS) and ship-to-stock (STS). Such frameworks make extensive use of the customer order decoupling point (CODP), which is the stock holding point that separates the part of the supply chain that responds directly to the customer from the part of the supply chain that uses forecast planning. The decoupling point can act as a strategic buffer against the variability in demand and an efficient way of scheduling standardised parts. Upstream from the CODP all products are produced to forecast, whereas downstream from the CODP all products are pulled by the end-user (Hoekstra and Romme, 1992, Christopher, 2000, Naylor et al., 1999, Mason-Jones et al., 2000, Olhager, 2003).

Stream 2 - Supply Chain Uncertainty

Uncertainties affecting supply chain operations are recognized as significant obstacles to achieving value for customers. Davis (1993) suggests that the underlying problem when managing complex networks is "the uncertainty that plagues them". Geary et al. (2002) support this by asserting that "uncertainty rules the supply chain". As a result, researchers in the field of operations management and supply chain management have examined sources and types of supply chain uncertainty and strategies to cope with such uncertainties (Prater et al., 2001, Childerhouse and Towill, 2004, van der Vorst and Beulens, 2002, Wilding, 1998, Mason-Jones and Towill, 1998). While it has been acknowledged that different types of supply chains are associated with different uncertainty profiles, the supply chain uncertainty literature has not addressed the particular sources of uncertainty and risk related to the ETO supply chain.

Literature Stream	Selection of Key Authors
1. Supply Chain Structures	(Lampel and Mintzberg, 1996, Martínez-Olvera and Shunk, 2006, Olhager, 2003, Porter et al., 1999, Rudberg and Wikner, 2004, Wikner and Rudberg, 2005, Yang and Burns, 2003)
2. Supply Chain Uncertainty	(Childerhouse and Towill, 2004, Dreyer and Gronhaug, 2004, Geary et al., 2002, Mason-Jones and Towill, 1998, Prater et al., 2001, Sanchez-Rodrigues et al., 2008, van der Vorst and Beulens, 2002, Wilding, 1998)
3. Supply Chain Flexibility	(Das and Abdel-Malek, 2003, Duclos et al., 2003, Lummus, 2005, Pujawan, 2004, Sanchez and Perez, 2005, Stevenson and Spring, 2007, Swafford et al., 2008, Tang and Tomlin, 2008, Vickery et al., 1999, Zhang et al., 2002)
4. Pipeline Management	(Berry et al., 1998, Aitken et al., 2005, Forrester, 1961, Christopher, 2005, Mason-Jones et al., 1997)

Table 1: The four literature streams with a selection of key authors

Stream 3 - Supply Chain flexibility

Early studies of flexibility focused on the value of flexible manufacturing systems, establishing the importance of flexibility as a manufacturing capability, and attempting to define it (Gerwin, 1993). This has been followed by a number of papers seeking to establish more detailed definitions of flexibility types and dimensions (D'Souza and Williams, 2000, Koste and Malhotra, 1999). More recently, the flexibility debate has refocused towards supply chain flexibility, suggesting that manufacturing is too narrow in its scope and that flexibility must be conceived in the broader context of the supply chain (Duclos et al., 2003, Pujawan, 2004, Sanchez and Perez, 2005, Vickery et al., 1999, Swafford et al., 2006). However, the supply chain flexibility field is still at an early stage, and consensus regarding definitions, scope, meaning and application has not yet been achieved.

Stream 4 - Pipeline Management

The phrase 'pipeline management' was originally coined by Forrester (1961) to describe the controlled flow of goods on demand. The pipeline has since been defined as the delay between an order being generated and the delivery of that order (Berry et al., 1998, Mason-Jones et al., 1997). Mason-Jones and Towill (1998) propose that all supply chains have two distinct pipeline lead times. The first is the order-to-raw-material supplier information transfer pipeline. The second is the product transfer pipeline from raw material to customer. The importance of pipeline management has been confirmed by a number of studies. Sterman (1989) found that the inclusion of pipeline information in a master production schedule ordering rule can have a dramatic impact on improving dynamic behaviour and reducing uncertainty. The findings of Berry et al. (1998) support this. A lack of consideration of the pipeline can lead to costly swings in supply, production and inventory, which in turn can lead to periods of poor customer service and excessive stock. Mason-Jones et al. (1997) argue that it is essential that ordering systems include pipeline feedback at every echelon of the supply chain. Typically, in a four level chain, demand amplification can be halved by divulging marketplace data throughout the pipeline in a timely manner. Christopher (2000) argues that lengthy and slow moving pipelines are unsustainable, and that two key strategies are, first, to reduce the length of the pipeline and, second, speed up the flow through that pipeline (Christopher, 2005).

RESEARCH METHOD

The research project was structured in two phases. Table 2 shows that, firstly, a case study phase was conducted, and then, secondly, an evaluation phase, consisting of 7 interviews, was undertaken. The case study phase included a 10 week industrial secondment to a ETO organisation, 38 interviews with a range of companies from 2 supply chains, 8 brainstorming sessions, 15 site visits and participation in team meetings, supplier training days and company presentations. A fuller discussion of the research methods adopted can be found in Gosling et al. (2010 in press).

Research Method Phase	Purpose	Description
1. Case Studies	Develop and investigate framework	Two 'network co-ordinators', five projects and twelve 'supplier pipelines', were investigated across two ETO systems.
2. Evaluation Interviews	Assess the accuracy, completeness, value, fairness and perceived validity of the findings by external review.	Seven evaluation interviews were conducted using participants from a range of ETO industries

Table 2: Overview of the empirical research phases

As noted by Easterby-Smith et al. (2008), an underlying concern for researchers of all persuasions is that a piece of research stands up to outside scrutiny. According to Lincoln and Guba (1985) processes whereby data, analytic categories, interpretations and conclusions are tested with members of stakeholder groups, are a crucial technique for establishing the credibility and meaningfulness of research. The second phase of the research focuses on evaluation presentations that were made to key stakeholder groups to validate and evaluate the framework. The evaluation interviews are important as they provide a method for exposing the findings of the case research outside of the two case systems. The aims of this activity were to assess the accuracy, completeness, value, fairness and perceived validity of the findings by external review, evaluate the extent to which the findings can be generalised to different ETO sectors, evaluate the strengths, weaknesses, opportunities and threats associated with the research, enhance and enrich findings with evaluative empirical data and identify avenues for further research.

Potential participants were approached with standard email stating the above aims and giving a brief overview of the research findings. If this invitation was accepted a presentation was made to the participant. At the beginning of the presentation participants were reminded of the aims and the opportunity to ask questions and make comments was offered at any time during the presentation. If no comments were forthcoming the researcher prompted a response by probing for thoughts on key slides. Table 3 provides a summary of the evaluation interviews. This selection process was purposeful, and had the objective of gathering feedback from a range of sectors and a wide range of supply chain members. The ETO sectors identified through the literature review were construction, high tech, capital goods and shipbuilding industries. Potential interviewees were approached across these sectors, from a range of organisational types. The final interviewees were from a range of ETO sectors, house building, commercial buildings, civil engineering, government bodies and capital goods, as well as representing a range of organisation types including clients, manufacturers, network co-ordinators, design, logistics and organisational bodies.

Organisation	Sector				
	House-	Commercial	Civil	Gov-	Capital Goods

	building	Buildings	Engineering	ernment	
Client			Interviews 5 & 6		
Manufacturer					Interview 7
Network Co-ordinator			Interview 4		
Architect/Design engineer	Interview 1				
Logistics	Interview 2				
Organisational Body	Interview 3				

Table 3: Overview of evaluation interviews

The framework was developed using the literature streams outlined in the review, and by empirical research from the case study phase described in the previous section. Table 4 shows the literature stream, the research questions posed and the consequent steps in the framework.

Literature Stream	Research Question	Framework Step
Supply Chain Structures	1. What are the distinguishing features of an ETO supply chain?	Identify Supply Chain Structure
Supply Chain Uncertainty	2. What are the sources of project uncertainty in ETO supply chains?	Analyse Sources of Supply Chain uncertainty
Supply Chain Flexibility	3. How can flexibility be achieved in ETO supply chains?	Configure network with required Flexibility levels
Pipeline Management	4. How can organisations improve pipelines in ETO supply chains	Optimise Pipelines

Table 4: Linkages between research questions, literature streams and the framework

A FRAMEWORK FOR ACHIEVING APPROPRIATE FLEXIBILITIES TO MITIGATE THE UNCERTAINTIES IN ETO SUPPLY CHAINS

The framework is shown in figure 1. It shows four steps for achieving supply flexibility in ETO supply chains, and acts as a route map for companies to follow. The four steps are now discussed in turn including a brief overview of the findings of the case study phase.

Step 1 – Identify the supply chain structure

The need to match supply chain strategy with structure has been outlined in the literature review. Six different supply chain structures were identified. Accordingly, the first step is the framework is the identification of the decoupling point. This can be achieved, primarily, by considering the form of strategic stock in the supply chain and the extent to which different supply chain activities are customised or standardised for each order. The findings for this step are primarily reported in Gosling and Naim (2009b) and can be summarised as follows:

- The ETO supply chain operates in a project environment where each product is different to the last. Production dimensions of the supply chain are completely customised and the decoupling point is located at the design stage.
- Existing designs maybe modified to order or completely new designs are developed to order.
- An ETO supply chain can be rationalised as a system consisting of network co-ordinators, the specific projects that the network co-ordinator organisation is currently involved with and a network of supplier pipelines.

Step 2 – Identify the sources of supply chain uncertainty

The next step is to identify the uncertainties in the supply chain. This can be approached by categorising uncertainties according to the different sources of uncertainty articulated in the supply chain uncertainty circle: supply, demand, process, control and external uncertainties. The root causes of these different uncertainties can then be explored through cause and effect analysis. The relative importance of these uncertainties can be analysed by considering the likelihood that a negative effect will come to fruition and the impact that an uncertainty could have on time, cost, quality and sustainability performance measures. The findings for this step are primarily reported in Gosling and Naim (Gosling and Naim, 2009a) and can be summarised as follows:

- 42 generic uncertainties were identified comprising 9 control uncertainties, 7 demand, 3 external, 16 process and 7 supply uncertainties.
- A cause and effect analysis identified the causes of uncertainty.

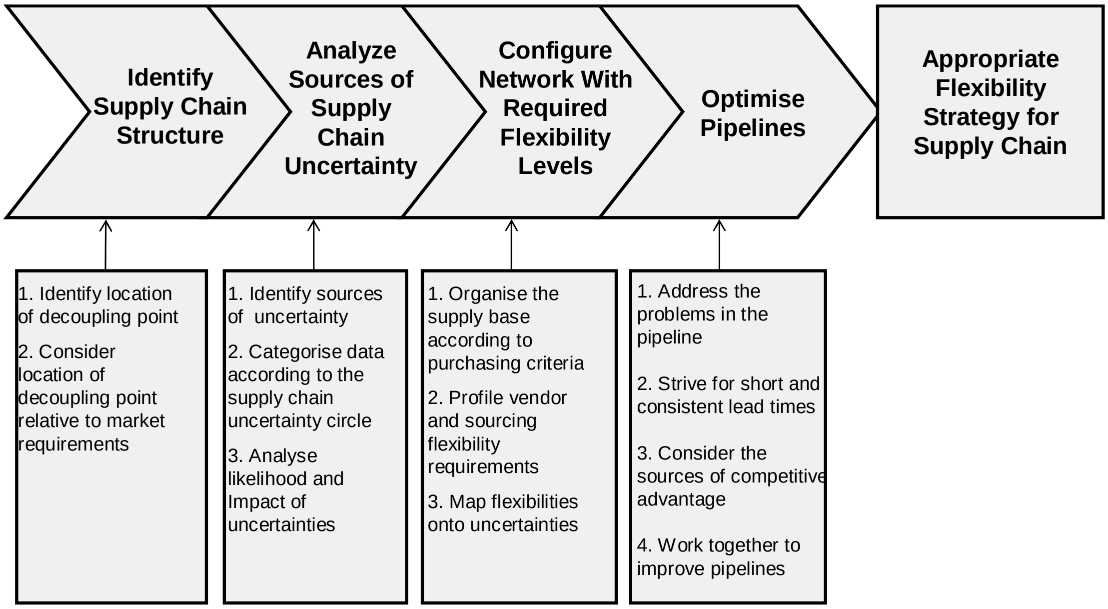

Figure 1: A framework for developing flexibility to mitigate uncertainty in ETO supply chains

Step 3 – Configure the network with required flexibility

The findings for this step are primarily reported in Gosling et al (2009 in press). This paper argues that supply chain flexibility can be rationalised using antecedents of vendor flexibility and sourcing flexibility. The former refers to specific types of flexibility relating to individual vendors that support manufacturing, warehousing or transport operations. The latter refers to the ability to reconfigure a supply chain network through selection and de-selection of vendors. A 3 tiered purchasing model was developed including approved suppliers, preferred suppliers and strategic partners. Vendor and sourcing flexibility can be integrated with the purchasing model. Our research from the case study phase concludes that using these definitions, supply chain flexibility can help to mitigate 23 of the generic uncertainties identified in step 2.

The first action for an organisation at this stage is to organise the existing supply base according to tiers. Gosling et al. (2010) argue for 3 tiers based on different criteria. Once this has been achieved, the development of supply chain flexibility can be addressed. It should also be noted that flexibility would be one of the criteria considered for placing suppliers in the different tiers. Network co-ordinators can then begin to develop strategic partners by offering formal training in flexibility in the required areas and capabilities. The next stage would be to develop sourcing flexibility capabilities for approved and preferred suppliers. The classification developed in the literature review suggests that the key abilities here are: ability to reconfigure the supply chain, ability to adapt to market requirements, ability to increase supplier responsiveness, ability to integrate the supply chain. The final stage is to establish a performance management system to address the promotion and demotion through performance monitoring. The experience of the network co-ordinator from system 1 suggests that KPIs and a dedicated supply chain manager are essential for this last stage.

Step 4 - Optimise pipelines
Network co-ordinators must fully understand the activities in the pipeline and the lead time implications. The pipeline includes an initial enquiry, design and approval, procurement, manufacture and assembly, transport to the site and then final site integration. The findings for this step are primarily reported in Gosling et al. (Gosling et al., 2007) and conclude that the design stage is the most variable and time consuming activity, and as pipeline lead-times increase, they get more variable. This step will involve understanding and documenting techniques, such as the input-output diagrams and process flow charting, simplification, by removing problems and improving information and material flows throughout the pipeline. The final stage is re-engineering to reduce problems in the pipelines. Four recommendations for pipeline improvement strategies are: 1. Reduce uncertainty by addressing the problems in the pipeline (the case study phase identifies 10 generic problems in the pipeline to address), 2. Strive for shorter and more consistent lead times, 3. Consider the sources of competitive advantage in pipeline improvement strategies (the case study phase identifies 10 potential sources of competitive advantage in the pipeline), 4. Work together to improve pipelines.

Evaluating the framework
The 7 evaluation interviews described in the research methods section provide important material for evaluating the framework, and enrich the answers to the research questions. The feedback from the evaluation interviews is summarised in table 5, and is structured according to research question and the relevant framework step.

RQ	Findings from Evaluation Interviews
RQ1 Step 1	• Interviewees were all able to relate their working environment to supply chain structures and the ETO supply chain. • Decoupling points could exist within the design phase of the ETO supply chain.
RQ2 Step 2	• The supply chain uncertainty circle is a useful and meaningful way of analysing uncertainty. • The 42 uncertainties identified are stable across ETO environments, but the relative importance of these uncertainties may differ between sectors. • In addition to time and cost, uncertainty also impacts on quality and sustainability performance dimensions.
RQ3 Step 3	• Definitions of vendor and sourcing are recognised as useful for 'operationalising' supply chain flexibility. • In addition to the 23 uncertainties, supply chain flexibility can also help to mitigate uncertainty related to damages. • The 3 tiered purchasing model is unsuitable for application in the public sector. • Unanswered questions include 'how much flexibility is required' and 'how much does flexibility cost?'
RQ4 Step 4	• The descriptive elements of the pipeline are accurate • Two further pipeline solutions were suggested: early involvements of suppliers in the design process and project bank accounts. • Solutions to problems in the pipeline may depend on the contract type and relationship type with the lead company.

Table 5: Summary of the findings from the evaluation interviews

All interviews confirmed the coherency of the framework, suggesting that the linkages between the steps were meaningful and useful. Important points were raised concerning individual elements of the framework. Overall, some of the major themes to emerge from the feedback include:

- Problems applying the framework to the public sector due to strict operational controls

- Further uncertainties and pipeline strategies/solutions were proposed
- Confirmation of the accuracy and meaningfulness of the characteristics of ETO supply chain, and the uncertainty circle
- The identification of further research questions relating to flexibility

CONCLUSION

This paper has presented a framework for achieving appropriate flexibilities to mitigate the uncertainties in ETO supply chains. The framework was developed through relevant literature streams and through a case research phase; it was then assessed via an evaluation phase. The main contribution has been the synthesis concepts related to supply chain structures, supply chain uncertainty, pipeline management and supply chain flexibility, making the important contribution of consolidating and establishing relationships between fields and concepts. While potential interviewees were targeted from construction, high tech, capital goods and shipbuilding industries, the study had much more participation from organisations from the construction industry, with many interviewees from other industries declining the invitation to participate. Future research directions include addressing the lack of coverage of all ETO sectors, and the development of change programmes for organisations.

REFERENCES

Aitken, J., Childerhouse, P., Christopher, M. & Towill, D. (2005) "Designing and managing multiple pipelines". *Journal of Business Logistics,* 26**,** 73.

Amaro, G., Hendry, L. & Kingsman, B. (1999) "Competitive advantage, customisation and a new taxonomy for non make-to-stock companies". *International Journal of Operations & Production Management,* 19**,** 349-371.

Berry, D., Evans, G. N. & Naim, M. M. (1998) "Pipeline Information Survey: a UK Perspective". *Omega,* 26**,** 115-131.

Childerhouse, P. & Towill, D. R. (2004) "Reducing uncertainty in European supply chains". *Journal of Manufacturing Technology Management,* 15**,** 585-598.

Christopher, M. (2000) "The agile supply chain". *Industrial Marketing Management,* 29**,** 37-44.

Christopher, M. (2005) *Logistics and Supply Chain Management: Creating Value-Adding Networks*, Financial Times Prentice Hall.

D'souza, D. E. & Williams, F. P. (2000) "Toward a taxonomy of manufacturing flexibility dimensions". *Journal of Operations Management,* 18**,** 577.

Das, S. K. & Abdel-Malek, L. (2003) "Modeling the flexibility of order quantities and lead-times in supply chains". *International Journal of Production Economics,* 85**,** 171-181.

Dreyer, B. & Gronhaug, K. (2004) "Uncertainty, flexibility, and sustained competitive advantage". *Journal of business research,* 57**,** 484-494.

Duclos, L. K., Vokurka, R. J. & Lummus, R. R. (2003) "A conceptual model of supply chain flexibility". *Industrial Management & Data Systems,* 103**,** 446-456.

Easterby-Smith, M., Thorpe, R. & Jackson, P. R. (2008) *Management Research,* London, Sage.

Fisher, M. L. (1997) "What is the right supply chain for your product?". *Harvard Business Review,* 75**,** 105-116.

Forrester, J. W. (1961) *Industrial Dynamics* Pegasus Communications

Geary, S., Childerhouse, P. & Towill, D. (2002) "Uncertainty and the Seamless Supply Chain". *Supply Chain Management Review,* July/August**,** 52-61.

Gerwin, D. (1993) "Manufacturing flexibility: A strategic perspective". *Management Science,* 39**,** 395-410.

Gosling, J. & Naim, M. (2009a) Sources of project uncertainty in engineer-to-order supply chains. *European Operations Management Association (EurOMA).* Gothenburg, Sweden.

Gosling, J., Naim, M., Fowler, N. & Fearne, A. (2007) "Manufacturer's preparedness for agile construction". *International Journal of Agile Manufacturing,* 10**,** 113-124.

Gosling, J. & Naim, M. M. (2009b) "Engineer-to-order supply chain management: A literature review and research agenda". *International Journal of Production Economics,* 122**,** 741-754.

Gosling, J., Purvis, L. & Naim, M. M. (2010) "Supply chain flexibility as a determinant of supplier selection". *International Journal of Production Economics,* In Press, Corrected Proof.

Hicks, C., Mcgovern, T. & Earl, C. F. (2000) "Supply chain management: A strategic issue in engineer to order manufacturing". *International Journal of Production Economics,* 65**,** 179-190.

Hoekstra, S. & Romme, J. (1992) *Integral Logistics Structures: Developing Customer Oriented Goods Flow,* London, McGraw-Hill.

Koste, L. L. & Malhotra, M. K. (1999) "A theoretical framework for analyzing the dimensions of manufacturing flexibility". *Journal of Operations Management,* 18**,** 75-03.

Lampel, J. & Mintzberg, H. (1996) "Customizing Customization". *Sloan Management Review,* 38**,** 21-30.
Lincoln, Y. S. & Guba, E. G. (1985) *Naturalistic Enquiry,* California, Sage Publications.
Lummus, R. J., Vokurka, L. K., and Duclos L.K. (2005) "Delphi study on supply chain flexibility". *International Journal of Production Research,* 43**,** 2687-2708.
Martínez-Olvera, C. & Shunk, D. (2006) "Comprehensive framework for the development of a supply chain strategy". *International Journal of Production Research,* 44**,** 4511.
Mason-Jones, R., Naim, M. & Towill, D. R. (1997) "The impact of pipeline control on supply chain dynamics ". *The International Journal of Logistics Management,* 8**,** 47-62.
Mason-Jones, R., Naylor, B. & Towill, D. R. (2000) "Engineering the leagile supply chain". *International Journal of Agile Management Systems,* 2**,** 54-61.
Mason-Jones, R. & Towill, D. R. (1998) "Shrinking the supply chain uncertainty circle". *IOM Control,* 24**,** 17-22.
Naylor, J. B., Naim, M. M. & Berry, D. (1999) "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain". *International Journal of Production Economics,* 62**,** 107-118.
Olhager, J. (2003) "Strategic positioning of the order penetration point". *International Journal of Production Economics,* 85**,** 319-329.
Porter, K., Little, D., Peck, M. & Rollins, R. (1999) "Manufacturing classifications: relationships with production control systems". *Integrated Manufacturing Systems,* 10**,** 189-199.
Prater, E., Biehl, M. & Smith, M. A. (2001) "International supply chain agility - Tradeoffs between flexibility and uncertainty". *International Journal of Operations and Production Management,* 21**,** 823-839.
Pujawan, I. N. (2004) "Assessing supply chain flexibility: a conceptual framework and case study". *International Journal of Integrated Supply Management,* 1**,** 79.
Rudberg, M. & Wikner, J. (2004) "Mass customization in terms of the customer order decoupling point". *Production Planning & Control,* 15**,** 445 - 458.
Sanchez-Rodrigues, V., Stantchev, D., Potter, A., Naim, M. & Whiteing, A. (2008) "Establishing a transport operation focused uncertainty model for the supply chain". *International Journal of Physical Distribution & Logistics Management,* 38**,** 388-411.
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 & Production Management,* 25**,** 681.
Sterman, J. (1989) "Modeling managerial behavior--misperceptions of feedback in a dynamic decision making experiment". *Management science,* 35**,** 334-365.
Stevenson, M. & Spring, M. (2007) "Flexibility from a supply chain perspective: definition and review". *International Journal of Operations & Production Management,* 27**,** 685-713.
Swafford, P. M., Ghosh, S. & Murthy, N. (2008) "Achieving supply chain agility through IT integration and flexibility". *International Journal of Production Economics,* 116**,** 288-297.
Swafford, P. M., Ghosh, S. & Murthy, N. N. (2006) "A framework for assessing value chain agility". *International Journal of Operations and Production Management,* 26**,** 118-140.
Tang, C. & Tomlin, B. (2008) "The power of flexibility for mitigating supply chain risks". *International Journal of Production Economics,* 116**,** 12-27.
Van Der Vorst, J. G. A. J. & Beulens, A. J. M. (2002) "Identifying sources of uncertainty to generate supply chain redesign strategies". *International Journal of Physical Distribution & Logistics Management,* 32**,** 409-430.
Vickery, S. N., Calantone, R. & Droge, C. (1999) "Supply Chain Flexibility: An Empirical Study". *The Journal of Supply Chain Management,* 35**,** 16-24.
Wikner, J. & Rudberg, M. (2005) "Integrating production and engineering perspectives on the customer order decoupling point". *International Journal of Operations & Production Management,* 25**,** 623.
Wilding, R. (1998) "The supply chain complexity triangle: Uncertainty generation in the supply chain". *International Journal of Physical Distribution & Logistics Management,* 28**,** 599-616.
Yang, B. & Burns, N. (2003) "Implications of postponement for the supply chain". *International Journal of Production Research,* 41**,** 2075 - 2090.
Zhang, Q., Vonderembse, M. A. & Lim, J. S. (2002) "Value chain flexibility: a dichotomy of competence and capability". *International Journal of Production Research,* 40**,** 561.

CONFIGURING NEXT GENERATION FOOD SUPPLY CHAINS: A RISK PERSPECTIVE

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ABSTRACT
An often overlooked aspect of today's business environment in general and supply chains in particular is uncertainty. The scenarios of loss of supplier, transport strikes, IT services failing, stock outs etc are becoming all too common. Looking at the future of supply chains, uncertainty and risk appear to be increasing and will play a crucial part in the configuration of next generation supply chain. This paper presents an alternative approach to supply chain configuration using supply chain risk as the minimising variable. Perishable nature of the product and high risk impact in the Food supply chain offers perfect conditions to situate the study. Also, current trends in food supply chains namely globalisation, consolidation and commoditization indicate greater need for inherent risk minimisation while configuring future supply chains (Roth.A.V 2008). Using data from secondary sources and semi-structured interviews with respondents in a food supply chain, this exploratory study identifies the factors which need to be considered while configuring such a supply chain. The relationship between these factors is developed into a research framework.

SUPPLY CHAIN CONFIGURATION

Configuration is defined as "an arrangement of parts or elements that gives the whole its inherent form" (Webster 2008). Chandra et al. (2007) describe the problem of supply chain configuration as one which relates to determining which units (e.g. suppliers, plants), their size, location etc to include in the supply chain. It also looks at establishing and maintaining the linkages between these units. Whilst configuring and even reconfiguring a supply chain has been a topic of significant interest amongst researchers the basis of the configuration is often limited. Beamon (1998) reviews the available literature pertaining to the design and optimization of supply chains and identifies several performance measures for supply chain modelling. These can be broadly classified either on the basis of cost reduction (minimize cost, maximise profit), inventory reduction (lean, agile) or customer satisfaction (target service level). The configuration of supply chains have typically been studied at two levels. Firstly, the macro level which looks at the system as a whole and aims to find solutions for strategic decision making. Secondly, the micro level looks at individual entities and aims at resolving specific problems with the aim of minimising a particular variable. A link between the interactions of the previous two levels may be formulated through coordination (Chandra, Grabis 2007). Srai(2008) lists the key elements of supply network configuration as the supply structure, the flow of material and information between the network, the roles, inter-relationships and governance between the network partners and the "value structure" of the product.

Although there are several studies especially in the field of modelling which look at supply chain configuration (Geoffrion, Powers 1995, Vidal, Goetschalckx 1997) they often assume the operational parameters to be deterministic. Supply chain modelling within uncertainty is gaining popularity with researchers (Cheung, Powell 1996, Van Landeghem, Vanmaele 2002) but they tend to look at individual characteristics rather than the chain in its entirety. In recent paper by Ritchie (2007) identifies that the aggregate Supply chain risk is a function of supply chain configuration therefore it stands to reason that minimising risks in the overall supply chain could be a valid basis for its configuration.

CURRENT TRENDS IN THE FOOD SUPPLY CHAIN

The food supply chain technically spans the entire 'farmer to fork' process. The exact supply chain path for a particular food product depends on the product characteristics, size and market power of the supply chain members (Maloni, Brown 2006). The peculiarities of the food supply chain stem predominantly from the nature of perishability of the products and the high levels of risk associated with food. Within the food supply chains there are some trends noted by researchers which have a bearing on risk. Roth et al. (2008) identified three trends namely those of **commoditisation**, **consolidation** and **globalisation**. **Globalisation** refers not only to global sourcing of raw material, but also food processing, packaging and transportation. **Consolidation** refers to the trend amongst food supply chain members to combine as many food categories as well as levels of the supply chain in pursuit of higher margins. There has been an increase in both vertical and horizontal integration within food chains. Young (2002) looks at the reasons behind vertical integration and identifies *changes in customer preferences, IT environmental pressures* and *reductions in global trade barriers* as some of the main reasons. **Commoditisation** refers to the distinction between food products as either value added or commodities. Commodities are traded as undifferentiated goods competing mostly on price for example grains for which traceability back to the farmer becomes particularly difficult. Another sub category of commoditisation is the batch mixing chains like those of milk powder where different batches of milk powder are aggregated across different suppliers.

Despite extensive food safety legislation, increasing customer concerns and its consequential costs imposed on society as a result of frequent food safety and security scares has lead to an increase in the focus on the causes, effects and prevention of hazards(Fearne, Hornibrook et al. 2001). Helen Peck (2006) in her report on business reliance in the food sector identified a big gap in the preparedness for business continuity management (BCM) as very few companies had adopted a proactive or preventative stance to crisis management and operated mostly in the reactive mode. One of the conclusions of her report was that the drive for efficiency and the just-in-time philosophy used by the food industry has progressively reduced stock levels throughout the supply chain - with the resulting damage to its resilience when an emergency occurs. The consolidation of distribution networks by food manufacturers and the trend towards using 3PL (Third Party Logistics) providers, and reducing distribution sites means that the loss of a site due to events such as a fire or flood could also cause a disruption in the supply chain. Statistically such events are predictable but as shown by Peck (2006), many managers pointed out that the trend toward fewer and larger production and distribution sites meant that the potential impact was increasing.

FUTURE TRENDS IN NEXT GENERATION FOOD SUPPLY CHAINS

Through an extensive literature search the following further trends have been identified as being critical to future food supply chains:

1) Increased dependence on Technology: The prominence of technology within food supply chains seems to be positioned to grow. However, currently the usage is directed more towards improving efficiencies rather than for supply chain management (Hill, Scudder 2002)). Another aspect of technology is the detection of contamination within food supply chains. The technology to measure contagions is ever increasing which brings more issues to light.Also Fritz et al.(2009) identify that vertical coordination between agri-food supply chains necessitates the use of advance IT systems for larger enterprises.

2) Increased interdependence: Due to closer vertical coordination the contracts tend to become longer and can span 5-10 years which are very different from traditional contracts (Young, Hobbs 2002). This entails a change in the relationship as well as interdependence between the entities. The producer is often supported by the chain in terms of technology and in turn is expected to respect the quantity, quality and timing of delivery. The production methods, documentation and on-farm audits form an integral part of such a relationship.

3) United approach to standards (HACCP, ISO, BRC, IFS): Reducing food contamination and recall is a major challenge for food supply chains. Given the risk impact of food products, food standards have become embedded in supply chains and often govern the way in which the entire supply chains operate. On the other hand Henson (2005) identifies the growing prominence of private standards as against public standards within food supply chains. He argues that this is happening primarily because of the growth of large retails as leaders in the industry, who in an attempt to achieve product differentiation find public standards either absent or inadequate. The introduction of Sanitary and phytosanitary measures (SPS) by the World Trade organisation attempts to deal with the two issues of providing "safe" food at the same time ensuring that the Food standards are not an excuse for protecting domestic producers. It allows countries to set their own standards but states that regulations must be based on science (http://www.wto.org/english/tratop_e/sps_e/sps_e.htm).

4) Traceability: Given the risk of product recall due to food contamination, the traceability within food supply chains is particularly important and has been the focus of several researchers (Kelepouris, Pramatari et al. 2007, Agarwal 2001, Wilson, Henry et al. 2008, Davies 2004, Dupuy, Botta-Genoulaz et al. 2005). Kelepouris et al.(2007) state that traceability will become a prerequisite for successful food enterprise in the years to come. Advances in technology have given rise to several traceability mechanisms like RFID tagging but these have not been taken up by many organisations. Davies(2004) suggests that this might be because the potential benefits of traceability offers are not comparable to the cost of work involved particularly for the small to medium enterprises(SME).

5) Training: Training is another trend which is particularly important in the food supply chains given their nature as operator error can lead to damage to the entire organisation and perhaps even to the sector. The case of peanut butter contamination at Peanut Corporation of America (PCA) (FDA, 2009) highlights the interconnectedness of the food sector as more than 2000 products had to be recalled.

6) Credence Attributes: Credence attributes within the food supply chain are defined as the characteristics like country of origin, food miles, ethical sourcing, organic food, carbon footprint etc (Roth, Tsay et al.2008,Henson 2005)which are changing the dynamics of supply chains and are positioned to grow. Glennie et al. (1996) suggests that the 1990s were characterised by the 'creation of myriad sub-groups of consumers in place of earlier and larger class centred constellations'. These 'new consumers' give more emphasis to aspects of quality and convenience than to price and quantity. The retail market growth of organic food rose a staggering 1508 percent from 1994 to 2005 (The Soil Association 2006).

7) Changing consumer habits: There is extensive evidence of changing food habits for example an interesting statistic out of UN FAO report states that the per capita intake of meat in China has grown from 20 Kg in 1980 to 50 Kg in 2007 (FAO 2008). This in turn can create huge pressures on the supply chain entities. Ready meals and processed food are sectors which have witnessed unprecedented growth in the past decade with imports highly processed goods showing a 27.6 percent growth between 1996 to 2005 (DEFRA 2007).

8) Greener Logistics: Green logistics is a more generic trend which isn't specific to the food sector but needs a mention given its importance in supply chain configuration for the future.

RESEARCH METHODOLOGY

The research stems from three research questions:

1. What are the trends affecting next generation food supply chains?
2. What are the risks affecting next generation food supply chains?
3. Can next generation food supply chains be configured with an aim to minimise risks?

The research approach is qualitative and conducted in two stages. The first stage includes secondary data analysis and second stage consists of semi-structured interviews with supply chain professionals within a UK confectionary supply chain. Secondary data in the form of extensive literature review and industry reports from within the field of supply chain design/configuration as well as supply chain risk management is used for content analysis. The data from these secondary sources and interviews was analysed using 'document summary sheets' and 'contact summary sheets' as suggested by Miles and Huberman (1984). Relevant units of meaning were extracted from each source. These units were in the form of quotes, words, and critical incidents (as a complete unit). Based on the risks affecting next generation food supply chains, a framework is developed which provides an insight into configuring food supply chains with the intention of minimising risks and eventually minimising the impact of the risks.

FOOD SUPPLY CHAIN RISKS

Broadly, Supply chain risks have been classified by Kliendorfer and Saad (2005) in two broad categories. First, risk arising from the problems of coordinating supply and demand and second are risks arising from disruptions to normal activities. Christopher and Peck (2003) on the other hand categorise risks into five categories. Firstly those that are Internal to the firm namely Process and control risks. Secondly those risks which are external to the firm but internal to the Supply network, these include demand and Supply. Lastly they categorise risks which are external to the network i.e. environmental.

Although a comprehensive list of risks in the food supply chain is absent a selection of major risks was identified through literature (Peck 2006), Agiwal and Mohtadi (Agiwal, Mohtadi 2008), Roth, et.al.(2008), BBC (2005), CNN (2006), Coghlan (2008), Fairclough (2008), Carey, 2007, Chan, *et al.,* 2008, Gale and Hu (2009), etc. are shown in the table below:

Risk	
Product contamination	Loss of IT
Product recall other than contamination	Unexpected economic forces
Pandemic	Unavailability of Raw material
Loss of Power/Water	Increased labour cost
Loss of premises	New food safety regulations
Loss/Disruption in logistics	Asset price collapse
Terrorism	Fuel price rise
Natural disaster	Loss of supplier
Strike action	

Table 1: Types of food supply chain risks

However what can clearly be seen is that these risks are not mutually exclusive and often materialisation of one risk leads to another for example natural disaster might lead to disruption in logistics or loss of premises. Another example could be that loss of IT might lead to faulty product leading to product recall. This meant that it would make more sense to analyse the risks with respect to their final impact if not managed correctly (Figure 1). Doing this analysis showed that the impact could lead to either recall of product or loss of revenue or a mix of both, finally resulting in a greater impact of 'Loss of reputation' and in some extreme cases 'Loss of business' (as in the case of the Peanut Corporation of America). In a survey conducted within the UK food supply chain (Dani, Deep, 2009), it was inferred that Loss of reputation (due to food contamination), Loss of power (electrical, oil, etc.), Loss of IT were the risks considered as high by the entities in the food supply chain.

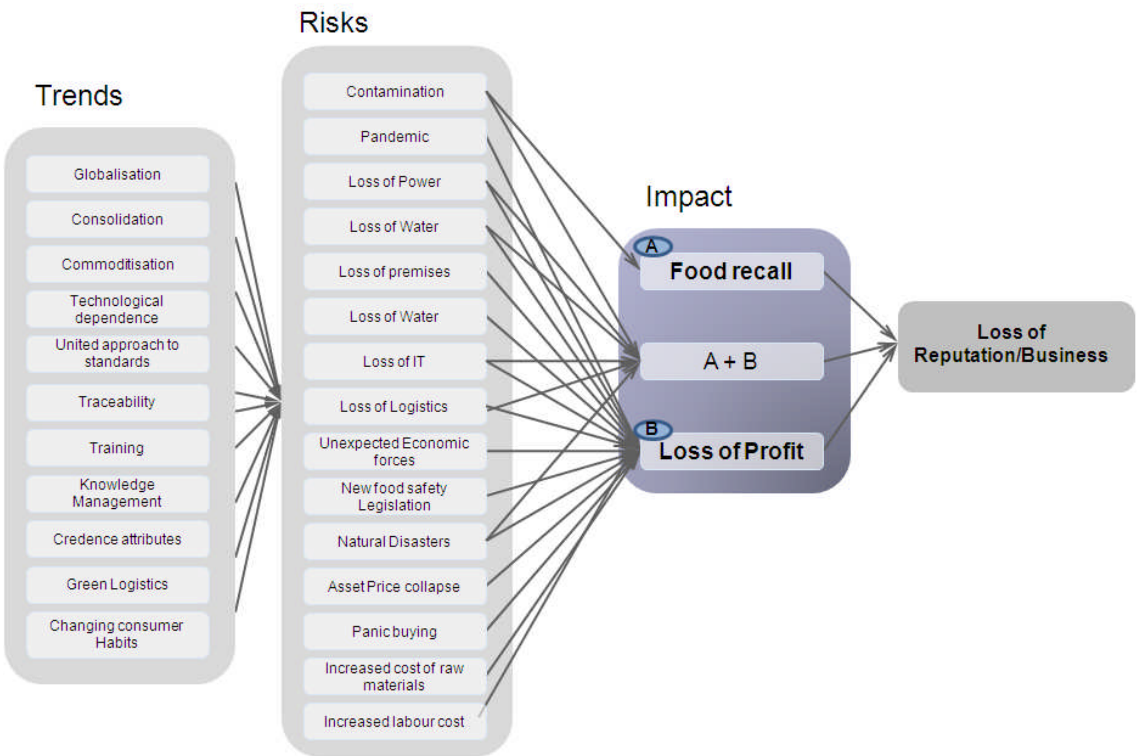

Figure 1: Impact of risks on the food supply chain

CONCEPTUAL MODEL (STITCH)

When configuring supply chains, a number of factors are considered to achieve optimum performance. Some supply chains may be configured around high quality norms, whereas some around low costs (Lean) and other may be configured around customer requirements (Agile, mass customised, Leagile, etc.). Currently, supply chains are rarely configured around minimising risks and /or minimising 'Loss of reputation'. By analysing the data available through secondary sources, semi-structured interviews and considering the future trends affecting food supply chains, a few factors are identified which will be essential for both minimising risks and eventually minimising the larger consequences (impacts) of the risks.

A framework (STITCH) has been proposed which brings these factors together which will provide a useful insight into configuring next generation food supply chains. The standard measures of Quality, Cost and Customer requirements are still valid and the new factors will work towards minimising the impact of risk along with supporting the standard measures. The factors are:

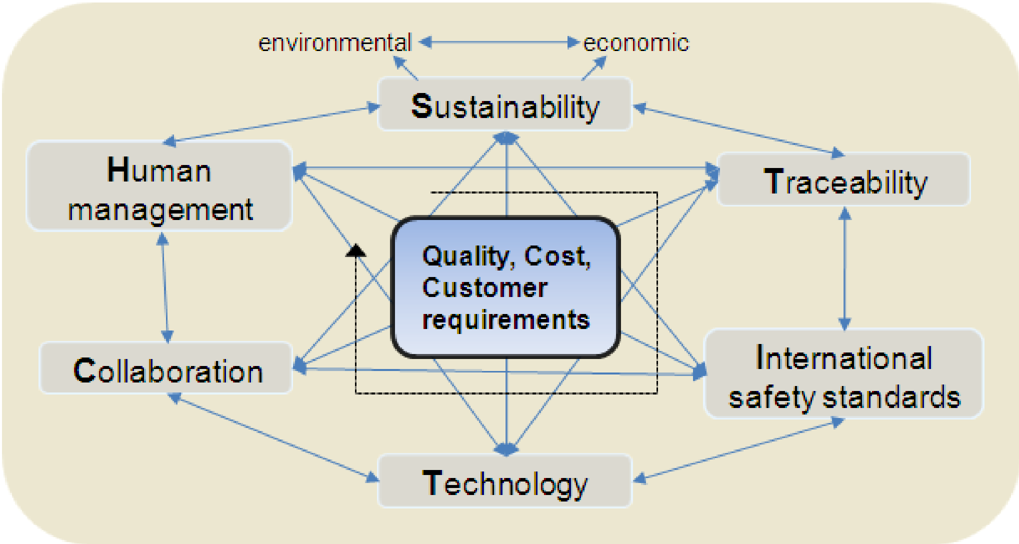

Figure 2: The STITCH model of configuring next generation Supply Chains

Sustainability: Limited supply of raw materials and increasing importance given to credence attributes makes sustainability especially important within the food sector. Sustainability will look at achieving both, economic sustainability (sourcing ethically, at appropriate costs, in appropriate quantities) and environmental sustainability (meeting green legislation, reducing wastage, reducing the carbon footprint, etc.)

Traceability: Traceability emerges as one of the key factors needed to configure the future food supply chains supply chains. Although traceability is linked to technology (RFID), collaboration and International safety standards it stands on its own right as a variable to minimise risks in the supply chain. Traceability is important as processes and systems need to be in place for information to permeate along the complete chain.

International safety standards: Although compliance to standards is common place within the food sector there is evidence of a next higher level of international standards mostly in the form of private standards which are more detailed and are a key to product differentiation. It was observed that the growth of these private standards is increasing and crosses local and economic boundaries. These international safety standards are therefore a key to risk minimisation for future supply chains. Also, as environmental, ethical and safety legislations gets tougher across international boundaries, configuring supply chains in compliance with these standards and also developing the capability of re-configuring based on changes to standards will be essential.

Technology: Technology is playing an increasing role in the supply chains however the use of technology for risk minimisation is an area which has a lot of further potential. It has two aspects: **risk detection** for example detection of contagions and **risk management** through using technology to monitor supply chain coordination and development of early warning systems. Technology also provides the platform for traceability in the supply chain.

Collaboration: Organisations are typically not keen on sharing their weaknesses and risk management practices. However, since food supply chains transcend international boundaries, it is essential for collaboration to develop for compliance with legislation, for food safety and in general reducing wastage in the system. Knowledge sharing and collaboration can be crucial in minimising as well as mitigating risks.

Human management: Human management in terms of both training of personnel and knowledge management appear to be a crucial risk minimisation variable. Human beings in the food supply chain are essential to keep up the compliance, use technology in the correct way, and use the appropriate sourcing guidelines. They are also a key to maintaining collaboration.

All the factors are essential in their own way and the supply chain can be configured keeping in mind only one factor. However, food supply chains are dynamic in nature and the final consequence of food contamination (which is also tied in with loss of life) makes it even more necessary to consider these factors together (as a STITCH) to configure the supply chain. Each factor has a bearing on each other. For e.g. for better traceability, there needs to be better technology, better collaboration and the motivation for the human beings to use the systems in place to make it happen. For achieving sustainability again human involvement (in the form of innovation and compliance) and better technology and improved collaboration are essential.

CONCLUSION

The paper has presented insights from a qualitative study conducted to study the trends and risks affecting next generation food supply chains, and suggest ways to configure the food supply chains to minimise risks. A conceptual model (STITCH) has been developed which considers the important factors relevant for minimising risks and suggestions are provided on how the factors work with each other for the configuration. Although, the model seems to be simplistic, the relationship between the factors as depicted through the links is complex and dynamic. The links between the factors are not tested and correlations may be sought between the various factors to realise the exact effect each has on the other factors. This will help individual supply chains to consider the relevance of the factors for their own scenarios and configure the supply chains based upon the weights applied to the factors. The next phase of the research will endeavour to operationalise the links and empirically test out the factors for their strength in alleviating food supply chain risks.

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REFERENCES

AGARWAL, V., 2001. Assessing the benefits of auto-ID technology in the consumer goods industry. *Cambridge, University of Cambridge,* .

AGIWAL, S. and MOHTADI, H., 2008. Risk Mitigating Strategies in the Food Supply Chain, 2008, American Agricultural Economics Association> 2008 Annual Meeting, July 27-29, Association.

CHANDRA, C. and GRABIS, J., 2007. Supply chain configuration: concepts, solutions and applications. Springer Verlag.

CHEUNG, R.K.M. and POWELL, W.B., 1996. Models and algorithms for distribution problems with uncertain demands. *Transportation Science,* **30**(1), 43.

DAVIES, C., 2004. Preparing for new EU traceability laws. *Supply Chain Europe,* **13**, 24-26.

DEFRA, 2007. *Food Statistics Pocketbook.*

DUPUY, C., BOTTA-GENOULAZ, V. and GUINET, A., 2005. Batch dispersion model to optimise traceability in food industry. *Journal of Food Engineering,* **70**(3), 333-339.

FAO, 2008. *Food Outlook May 2008.*

FEARNE, A., HORNIBROOK, S. and DEDMAN, S., 2001. The management of perceived risk in the food supply chain: a comparative study of retailer-led beef quality assurance schemes in Germany and Italy. *Management review,* **4**, 19ą36.

FDA, 02/26, 2009-last update, FDA investigation: peanut product recalls. Available: http://www.fda.gov/oc/opacom/hottopics/salmonellatyph.html#update [02/01, 2010].

FRITZ, M. and HAUSEN, T., 2009. Electronic supply network coordination in agrifood networks:: Barriers, potentials, and path dependencies. *International Journal of Production Economics,* **121**(2), 441-453.

GEOFFRION, A.M. and POWERS, R.F., 1995. Twenty years of strategic distribution system design: An evolutionary perspective. *Interfaces,* , 105-127.

GLENNIE, P. and THRIFT, N., 1996. Consumers, identities, and consumption spaces in early-modern England. *Environment and Planning A,* **28**, 25-46.

HENSON, S. and REARDON, T., 2005. Private agri-food standards: Implications for food policy and the agri-food system. *Food Policy,* **30**(3), 241-253.

HILL, C.A. and SCUDDER, G.D., 2002. The use of electronic data interchange for supply chain coordination in the food industry. *Journal of Operations Management,* **20**(4), 375-387.

KELEPOURIS, T., PRAMATARI, K. and DOUKIDIS, G., 2007. RFID-enabled traceability in the food supply chain. *Industrial Management and Data Systems,* **107**(2), 183.

MALONI, M.J. and BROWN, M.E., 2006. Corporate social responsibility in the supply chain: an application in the food industry. *Journal of Business Ethics,* **68**(1), 35-52.

MILES, M. B. and HUBERMAN, A. M. Qualitative data analysis: an expanded sourcebook, 1994 (Sage Publications, Thousand Oaks, California).

PECK, H., 2006. Resilience in the Food Chain: A Study of Business Continuity Management in the Food and Drink Industry. *Final Report to the Dep.for Environment, Food and Rural Affairs, Dep.of Defence Management & Security Analysis, Cranfield University, Shrivenham,* , 1–193.

RITCHIE, B. and BRINDLEY, C., 2007. An emergent framework for supply chain risk management and performance measurement. *Journal of the Operational Research Society,* **58**(11), 1398-1411.

ROTH, A.V., TSAY, A.A., PULLMAN, M.E. and GRAY, J.V., 2008. Unraveling the food supply chain: Strategic insights from China and the 2007 recalls. *The Journal of Supply Chain Management,* **44**(1), 22-39.

SRAI, J.S. and GREGORY, M., 2008. A supply network configuration perspective on international supply chain development. *International Journal of Operations and Production Management,* **28**(5), 386.

THE SOIL ASSOCIATION, 2006-last update, Organic market report 2006. Available: http://www.soilassociation.org/web/sa/saweb.nsf/94b4d558e66793c680256fa800349138/40a939de49ee98fa80257338004b4408!OpenDocument.

VAN LANDEGHEM, H. and VANMAELE, H., 2002. Robust planning: a new paradigm for demand chain planning. *Journal of Operations Management,* **20**(6), 769-783.

VIDAL, C.J. and GOETSCHALCKX, M., 1997. Strategic production-distribution models: A critical review with emphasis on global supply chain models. *European Journal of Operational Research,* **98**(1), 1-18.

WILSON, W.W., HENRY, X. and DAHL, B.L., 2008. Costs and risks of conforming to EU traceability requirements: the case of hard red spring wheat. *Agribusiness-Bognor Regis,* **24**(1), 85-101.

WEBSTER. Merriam-Webster's collegiate dictionary.
10th ed. Springfield, MA: Merriam-Webster; 2000.

YOUNG, L.M. and HOBBS, J.E., 2002. Vertical linkages in agri-food supply chains: changing roles for producers, commodity groups, and government policy. *Review of Agricultural Economics,* **24**(2), 428.

STRATEGIC FLEXIBILITY CAPABILITIES IN THE CONTAINER LINER SHIPPING SECTOR

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INTRODUCTION

Flexibility "reflects the ability of a system to change or react with little penalty in time, effort, cost or performance" (Sanchez and Perez, 2005). It is a concept that has been predominantly researched in relation to the manufacturing sector, although in recent years studies have been undertaken which have sought to explore the subject in relation to the wider enterprise; for example flexibility in freight transport (Naim et al, 2006 and Lagoudis et al, 2010) and flexibility in the supply chain (Stevenson and Spring, 2007). This paper reflects on the notion of flexibility from the perspective of the major liner operators in the container shipping sector and asks how flexible strategies can be deployed to maintain the stability of the maritime component in the international supply chain. Current trading for liner operators on the major shipping lanes is very challenging. The problems faced are not just as a result of the global recession following the banking crisis of 2008 and consequent substantial falls in demand for container shipping. They also stem, as the study will portray, from over supply of shipping capacity, important changes in regulation and, perhaps significantly, an inability of the liner shipping operators to be flexible enough to respond adequately to current trading conditions. Indeed, the notion of the degree of flexibility inherent in the operating strategies of the major liner shipping operators will be the focus of the study.

The paper is structured as follows. Initially, the flexibility concept is introduced. The section highlights that there have been no former studies that have examined the notion of flexibility from the perspective of the liner shipping operators. Next, the operating dilemmas facing liner container shipping operators attempting to conduct business on the major global shipping lanes are outlined, with the East-West, Asia – Europe route selected as the study's major focus. The principal reasons for the current significant challenges to profitability are then covered. These are categorised into three areas: demand challenges, supply problems, and regulatory changes. Flexibility strategies which may be adopted by liner operators to better adapt to the commercial scenario they face are identified (developed from Naim et al's (2006) typology of transport flexibility). From this foundation the principal flexibility types which may be used to restrict supply capacity by container shipping companies in their attempts to restore a better equilibrium to the market for international container shipping movement are explored. The bases for these findings are from two principal sources: leading trade based reports and a semi-structured interview with the UK Managing Director of a leading shipping logistics company. Finally, conclusions are drawn and the implications, which stem from the heightened risks of the inability of the liner shipping operator system to quickly adapt to changes in market conditions, reflected upon.

THE FLEXIBILITY CONCEPT

Flexibility can be conceived of in many ways. For example, De Toni and Tonchia (1998) envisage flexibility as the ability of an organisation to be reactive (adapt) or be proactive (change). They also note that it can be either of an internal type, the degree of flexibility capability an organisation possesses, or external to the organisation, defined by the degree of flexibility as perceived by the customer. The limited studies of flexibility within transport provision so far have largely studied the notion of flexibility from an external customer perspective (Naim et al, 2006, and Lagoudis et al, 2010), although Naim et al's (2006) study did attempt to categorise internal flexibility types in relation to transport. This paper takes a largely internal flexibility perspective and seeks to develop a clearer understanding of how transport companies, with a particular focus on ocean liner container carriers, can utilise both proactive and reactive flexibility capabilities to cope with demand uncertainties, i.e. maintain the stability of the maritime component of the international supply chain for container shipments. This is with particular reference to the challenging market which players in the sector are contending with today.

BACKGROUND TO THE CONTAINER LINER SHIPPING MARKET

International trade has not only grown in terms of volume but has also seen changes in the location of production and consumption driven largely by the shift of capital to manufacturing locations that offer greater cost advantages. The global nature of production, particularly for manufacturing, has also had an impact on the scale and network of international seaborne transport: more than 80 per cent of world trade by volume moves by sea (UNCTAD, 2008). The output of manufacturing that is carried across large distances for consumption is located in different parts of the world.

There are several categories of seaborne cargoes, but an increasing proportion of this sector is borne by container shipping, which now accounts for around one third of world trade by value (WSC, 2010). Global container shipping companies principally operate in three major trade lanes which are the transatlantic, transpacific and the Europe - Far East. This paper examines the risks involved for the carriers who run the vessels, taking the key East-West trade route as a case setting, and explores how capable their flexibility strategies are to allow them to respond and adapt to the changing, and challenging conditions in which they operate. Initially, to establish the context for the study, the current operating environment is set out, divided into demand challenges, supply side problems and regulatory changes:

DEMAND CHALLENGES

The demand for global seaborne container transport has historically risen above world GDP rates for virtually every year since the 1970's when its inception as a significant mode of international cargo movement commenced. On average, over the 35 years to 2007 annual growth in TEU shipped was +9%: a rule of thumb used by many forecasters in the sector was for global container shipping demand rates to equate to world GDP growth rate x 2 + 3%, which works out as +9% for this period (Kerr-Dineen, 2003).

However, this expectation that the continual very positive growth would carry on almost indefinitely, which to some extent had built up within the container liner shipping market, was questioned by the events following the global banking crisis of 2008. This had a significant impact on container shipping volumes. Table 1 highlights this fact from the perspective of the Europe–Far East shipping lane where volumes on the principal East–West route dropped by an unprecedented 19% in 2009 compared to a year earlier. Interestingly, the table also shows that although demand rates are expected to be positive again from this year onwards, the forecast still means that even by 2012 the volume on the East-West lane will still be 6% below TEU levels experienced in 2008. Although, the East-bound leg is slightly more positive it is the principal West-bound route which is the defining service and largely determines the profitability of the sector.

Year	FE to NE (million TEU)	Annual % change	NE to FE (million TEU)	Annual % change
2008	8.876	+3%	3.322	+9%
2009	7.157	**-19%**	3.281	-1%
2010	7.743	+8%	3.723	+13%
2011	8.019	+4%	4.027	+8%
2012	8.347	+4%	4.227	+5%

Table 1: Far East to/from Northern Europe container shipping trade in TEU (source Containerisation International, 2010 – table complied by authors)

FE = NE & SE Asia & neighbouring countries. NE = Great Britain, northern continental Europe & Scandinavia

In conclusion, the trading climate faced by the operators today, even without any additional supply-side problems or regulatory changes, is extremely challenging.

SUPPLY SIDE PROBLEMS

Inaccurate Forecasts

At the end of April 2007, Drewry, a leading shipping consultant (in keeping with the general sentiment of the industry at the time) predicted that annual container volume growth on the Far-East to Northern Europe trade lane would be +11.1% in 2007, +9.3% in 2008 and +9.7% in 2009 (Davidson, 2007). Indeed, as well as predicting "strong growth in container volumes" they highlighted that due to the long planning horizons of the major infrastructure required to adequately deal with these volume increases, every effort should be made to anticipate and pursue the investments required for the sector to prosper, such as in ship-building and in infrastructure development around ports. As has been noted above, these forecasts substantially over-predicted actual demand.

From the liner shipping operators perspective forecasts are critical in that they base their demand for new ships on these predictions. However, a new ship takes at least two years to commission and build. Therefore, inaccurate forecasting was one of the principal causes of over-supply in container carrying capacity from 2008 onwards.

The Move to Larger Ships

The inaccurate forecasting was however, not the only supply side issue pertinent at this time. The second quite profound trend was the strategic switch being adopted by many of the leading liner shipping companies to move to the larger post-panamax ships (vessels with a beam larger than 32.3m unable to transit the Panama canal). This deployment trend was driven by their perceived need to exploit economies of scale to better cater for an ever increasing growth of world trade (Frankel, 1997; Kerr, 2009; Gardiner, 2009). For example, by 2005 there were 390 post-panamax container ships, while this had grown to 683 by the end of the first half of 2009. The move to larger ships over the history of the container shipping sector is shown in Table 2.

Year	**Average Ship Size**	**Largest Vessel**
1980	975 TEU	3,000 TEU
1990	1,355 TEU	4,400 TEU
2000	1,740 TEU	7,200 TEU
2010 (April)	3,000 TEU	14,000 TEU

Table 2: Growth in container ship size (Davidson, 2007 and CI, 2010)

On the focus route (the East-West Asia-Europe shipping lane) of this paper the profile of vessel size by category by April 2010 is summarised in Table 3. In total 259 fully cellular vessels, with a total TEU capacity of 2,012,950 currently operate on this leg. Interestingly, the adoption of ships above 9,000 TEU has been largely driven by the three leading carriers: Maersk, MSC and CMA CGM.

Vessel Size Category (TEU)	**Numbers (FE-Europe)**
=>14,000	9
11,000 - < 14,000	14
9,000 - < 11,000	34
7,000 - < 9,000	103
5,000 - < 7,000	51
<5,000	48
Total (ship numbers)	**259**
Total TEUs	**2,012,950**

Table 3: Vessel Size category deployed in Far East (FE)-Europe route (Source CI, 2010)

REGULATORY CHANGES

The business model for the movement of containers internationally by liner shipping companies has been characterised by their cost structure, which is predominantly a function of the scheduled basis of their operations (Gardner et al., 2002). In such an industry it is difficult for any one player to differentiate themselves compared to the competition and therefore many players have only been able to survive through collaborating with other operators to maintain their fill utilisation rates, critical for their operating profitability. These collaborative mechanisms have included cooperative frameworks within liner shipping conference agreements, where prices are fixed and supply is regulated, operational efficiency agreements, such as container consortia (Gardner et al., 2002) and trans-national alliances, where carriers in the main East-West arterial routes have established, through their cooperation agreements, exemptions from anti-trust rules of the larger economies, such as the USA and the European Union. However, now for carriers serving EU ports the repeal of the anti-trust rules by the EU in October 2008 has now ruled that the conference agreements are unlawful.

SUMMARY

The challenges of the current marketplace which have arisen predominantly as a result of the demand, supply and regulatory issues discussed above have produced a very difficult operating environment for liner shipping operators since 2008. One of the means of dealing with such external "environmental" uncertainties is to execute flexible capabilities which allow organisations to adapt and cope with the challenges they may face. However, the degree of commercial difficulty faced by industry players in the liner shipping sector is virtually unprecedented in the sector's short history since its inception around 40 years ago. The question which follows is to what degree the liner shipping operators, and the industry system as a whole, been able to use flexible tactics to adapt and react to the economic scenario that has been encountered to cope with the commercial challenges that they face adequately and with minimum penalty. To act as a foundation to address this question the next section sets out a range of strategies/tactics that could be deployed by liner shipping organisations to elevate their flexibility capacity.

FLEXIBILITY STRATEGY TYPE MENU

A menu of flexibility strategies to either increase demand and/or restrict supply for international container shipping movements, which could be deployed by container liner shipping organisations to cope with environmental uncertainties discussed above is detailed in Table 4. This is developed from Naim et al's (2006) definitions of transport flexibility internal types, which was based primarily on land based freight transport such as road/rail. Contributions of this table include revised menu of flexibility method/tools for use by container liner shipping operators and three new flexibility types:

- **Horizontal Inter-organisational Flexibility** - the degree to which the use of infrastructure can be coordinated between users (previously this was part of Naim et al's (2006) Temporal flexibility type)
- **Mobility Flexibility** – the ability to re-deploy a transport asset – for container liner shipping this includes an ability to switch container ships to other shipping lanes
- **Ownership Flexibility** – the ability to utilise outsourced agents to minimise risk of under-utilisation of asset exposure – in shipping this involves the degree to which chartering arrangements can be set up.

METHODOLOGY OF RESEARCH

The research objective will be to explore the extent to which the flexibility types can be deployed by operators to restrict supply in a market, characterised by over-supply (as well as under demand). The study will use secondary data taken from industry sources to reflect the empirical developments taking place in the sector to address this. Knowledge will also be supplemented by a case study based on a semi-structured interview with the UK Managing Director of a leading shipping logistics company.

FINDINGS AND ANALYSIS

The deployment of flexible strategies by the leading container liner shipping companies will be examined below. The particular focus of analysis will be on the principal strategies which could be deployed to "restrict supply", which focus on three flexibility types: Ownership, Temporal and Capacity.

Internal Transport Flexibility Types and Definitions **1:** Naim et al (2006); **2:** Feitelson and Salomon (2000); **3:** Morlok & Chang (2004); similar to	**Flexibility method/tool in the liner shipping operating sector to deal with a marketplace**	**Impact Type**	
		Increases **demand** for	Restricts **supply** for

Expansion Flexibility by Groothedde et al. (2005); **4:** Peppers and Rogers (1997);	**characterised by under demand / over capacity**	container shipping services	container shipping services
Mode[1] Ability to provide different modes of transport	Ability to ***attract cargo from being shipped by*** different modes of transport	Yes	-
Fleet[1] Ability to provide different vehicle types to carry different goods	Ability to ***attract cargo from being shipped by other types of ships*** (e.g. bulk/specialist)	Yes	-
Vehicle[1] Ability to configure vehicles to carry products of different types / to cater for different loading facilities	Ability to configure ***containers*** to carry products of different types	Yes	-
Node[2] Ability to plan, approve and implement new nodes in the network	Ability to plan, approve and implement new ***sea port*** nodes and ***new hub sea ports*** in the network	Yes	-
Link[2] Ability to establish new links between nodes	Ability to establish new links between ***sea port*** nodes	Yes	Yes
Temporal[2] Ability to sequence infrastructure investment and the degree to which the use of such infrastructure requires coordination between users	Ability to ***re***-sequence infrastructure investment – e.g. amend ship-building *(N.B. the degree to which the use of infrastructure can be coordinated between users is moved to a new category – horizontal inter-organisational flexibility)*	-	Yes
Horizontal Inter-Organisational	The degree to which the use of infrastructure ***can be*** coordinated between users	-	Yes
Capacity[3] Ability of a transport system to accommodate variations or changes in traffic demand	Ability of the ***container liner shipping*** transport system to accommodate variations or changes in traffic demand	-	Yes
Routing[1] Ability to accommodate different routes	Ability ***to remove scheduled services***	-	Yes
Communication[4] Ability to manage a range of different information types	Ability to manage a range of different information types	Yes	Yes
Mobility Ability to re-deploy a transport asset	***Ability to switch container ships to other geographic areas***	-	Yes
Ownership Ability to utilise outsourced agents to minimise risk to under-utilisation of asset exposure	***Ability to involve chartering arrangements for container ship ownership***	-	Yes

Table 4: Interpreted and modified transport flexibility types (sourced from Naim et al., 2006 and adapted by the authors)

Ownership Flexibility Type

One of the key tactics for enhancing flexibility to cope with demand uncertainty is to move the risk of vessel ownership to third parties (tramps): this is termed "chartering" in the liner shipping sector. Through the last decade a greater proportion of the world container movement capacity was accounted for by the chartering market as liner operators looked to restrict their risk exposure. However, when the market downturn emerged in 2008/2009 most of the liner shipping companies still retained significant proportions of their fleets under their ownership. Reflecting upon this however, it is interesting to observe that there were quite widely differing tactics in this area. Table 5 summarises the position of owner/charter fleet proportions as at April 2010. It suggests that the top four liner shipping operators had evolved so that over half of their ships were charter based – 79% and 74% for CMA and APL respectively. However, for other operators such as Evergreen and NYK the position was different – over half of their fleet utilisation was owner dominated suggesting this flexibility strategy had been less fully deployed. A caveat which should be mentioned here, and a potential area for future research, is the terms of chartering. A chartering length of more than a year would still leave liner shipping operators vulnerable to market downturns such as the world recession in 2008/2009 which, as has been noted, was largely unpredicted. To conclude, it would seem likely that chartering will be further pursued in future years, with chartering increasing in importance, lengths of chartering contracts decreasing, chartering rates falling (due primarily to overall surplus in world carrying capacity) and a move to become more "light-asset" based for some operators would not be a surprise.

Carrier	Owned		Chartered		Chartered/Total Fleet (ships) %
	TEU	Ships	TEU	Ships	
Maersk	1,067,324	196	713,201	221	52%
MSC	753,468	180	774,869	205	53%
CMA	321,825	61	637,173	227	79%
APL	152,409	36	397,204	101	74%
Evergreen	344,388	94	229,428	65	41%
NYK	256,266	50	91,610	22	31%

Table 5: Chartered tonnage for selected carriers (top 5) in April 2010 (Source: CI, 2010)

Temporal Flexibility Type

Temporal flexibility is defined as the ability to re-sequence investment in infrastructure in vessels. For the container liner shipping sector this is exemplified by the degree new build commissions which can be amended. This is very important as it impacts upon the level of growth in container shipping movement capacity through new builds. The size of new builds in relation to the total world fleet is substantial: in September 2009 the order book of 962 vessels (5.2 million TEU) represented 41% of total fleet capacity (Clarkson, 2009). Restriction tactics include: reducing new build requests, extending due dates and even reneging on contracts.

Size Category	Maersk	MSC	CMA-CGM	APL	Total
1500- <4000	6		12		18
4000- <6000	20	10	-	2	32
6000 - <8000	16		6		22
8000 -< 11000	9	2	10	8	29
11000 - <13000		9	17		26
=>13000	8	17	7		32
Total	**59**	**38**	**49**	**10**	**156**
Total (top 20)					**368**

Table 6: Order book (Apr/2010) for the top 5 carriers (in no. of ships) (Source: CI, 2010)

Firstly, for new build commissions it was found that there had been no new container ship orders placed from September 2008 to the present date (Containerisation International, 2010 (April)). Secondly, on extending new build due dates, it was evident that many players had worked with ship-yard builders to delay delivery. For example, delivery slippage was calculated at running at about 12% in the first eight months of 2009 (Clarkson, 2009). Table 6 summarises the outstanding order book for the top 4 carriers and world fleet as at April 2010. It shows that there were still 368 vessels still to be delivered. To gain a further handle on delivery slippage Table 7 shows outstanding delivery due dates. This suggests that whilst pressure may have been placed to delay delivery, actual extra capacity being introduced each year remains at exceptionally high levels: "overall container capable capacity is set to expand by 9.6% in 2009 and 10.5% next year" (Clarkson, 2009). This indicates that despite efforts to be more flexible the industry is in reality still temporally inflexible as the sector's carrying capacity is still growing at a fast rate despite the cooling off of demand pressures.

Carrier	**On Order**		**Delivery 2010**		**Delivery 2011**		**Delivery 2012**	
	TEU	Ships	TEU	Ships	TEU	Ships	TEU	Ships
Maersk	410,550	59	82,940	11	247,360	37	80,250	11
MSC	414,800	38	168,000	14	230,150	21	16,650	3
CMA	448,684	49	296,304	34	89,380	10	63,000	5
APL	89,200	10	9,200	2	-	-	80,000	8
World Fleet	4,582,483	904	1,814,343	478	1,576,028	269	994,440	131

Table 7: Delivery schedule for top 4 carriers (in number/TEU) (Source: CI, 2010)

Capacity (Restriction) Flexibility Type

Delaying new build commissions is a temporal flexibility type, yet it can also be classified as a capacity flexibility type. The section below discusses other means liner shipping companies can deploy to restrict capacity, split into direct and indirect methods.

Direct Methods

There are three principal methods of direct methods of restricting capacity which can be summarised as laying up surplus carrying capacity to help restore equilibrium to the market: moth-balling (de-commissioning for more than 20 days), short-term (less than 20 days) lay up and scrapping. For moth-balling Table 8 summarises the position for the world container fleet for March 2010. It shows that the total number of ships idled for more than 20 days stood at 542 vessels representing 1.19 million TEU and is about 9.1% of world capacity. It also indicates however, that the owner operators are less exposed to moth-balling compared to the chartering sector. Only 6.6% of owner operators' TEU capacity was moth-balled at this date compared to 11.3% of tramp owners. It indicates that the owner operators have been able to use the chartering market to some extent to provide some flexibility buffering to better stabilise their position.

TEU Size Range	**Owner Operator**		**TrampOwner/ Unknown**		**Total**	
	No. of ships	**TEU**	**No. of ships**	**TEU**	**No. of ships**	**TEU**
<=1000	55	26,759	131	70,431	186	97,180
1001-2500	36	55,921	124	216,361	160	272,282
2501-4999	41	158,152	100	311,084	141	469,236
>=5000	29	182,912	26	165,441	55	348,353
Total	161	423,734	381	763,317	542	1,187,051
% owner fleet	-	6.6%	-	11.3%	-	
% world fleet	-	3.2%	-	5.8%	-	9.1%

Table 8: Vessels Laid-up March 7 2010 (Source: CI, 2010)

Information was less readily available for short-term lay up although it is clearly a tactic that is deployed, the advantage being that the vessel can be more quickly re-deployed when the market can accommodate extra scheduled services. In terms of scrap rates, the relatively young age of the container fleet restricts the use of this tactic. Scrap rates were still at a high however, 58 ships (Clarkson, 2009) being demolished in 2008 (a 375% increase compared to the average of 12.25 ships a year over the four preceding years), but this still represents only 1.2% of the world cellular fleet, which shows that as a flexible tactic to restrict total supply capacity it was only a token measure.

Indirect Methods

Indirect methods are tactics which can be deployed by liner shipping operators which have the effect of reducing potential carrying capacity of the world fleet, principally by slowing down operations. Tactics include: slow steaming and creating extra loops. These tactics have to be carefully executed as although they may restrict carrying capacity capability and thus help restore a better supply/demand equilibrium to the market they also restrict the earning potential for each vessel.

CONCLUSIONS

The study has reviewed the flexibility capability of container liner shipping operators as they face unprecedented business challenges in today's international container shipping market. A combination of demand "cooling", supply "inflation" and regulatory "tightening" have imposed unprecedented new pressures on the container shipping business model, previously used to continual growth since the industry's inception. As a measure of the pressures felt, liner companies' losses were $11 billion for 2009 (Barnard, 2009). In this sector, although certain flexibility tactics have been deployed, for example, Ownership Flexibility through chartering, Capacity Flexibility via moth-balling and other tactics and Temporal Flexibility by delaying new builds, these largely reactive strategies have clearly not been enough to stabilise the supply side of the market. Future research could focus on what more could have been done to proactively prepare the liner shipping companies for this kind of market and what are the implications in the medium to long term for liner shipping companies currently operating in this sector.

REFERRENCES

Barnard, B. (2009) Container Carrier Losses Reach $11 Billion. The Journal of Commerce, Dec 22nd http://www.joc.com/maritime/container-carrier-losses-reach-11-billion accessed on 11/05/10

Clarkson (2009) Shipping Review and Outlook. Autumn 2009 London
Containerisation Int. (2010) www.ci-online.co.uk/default.asp?URL=news/showNews.asp?News_ID=27311

Davidson, N. (2007) World Container Cargo Prospects 25th IAPH World Ports Conference, Houston

De Toni, A. and Tonchia, S. (1998) Manufacturing Flexibility: a Literature Review International Journal of Production Research, Vol. 36 pp. 1587-1617

Feitelson, E. and Salomon, I., 2000, The Implications of Differential Network Flexibility for Spatial Structures, Transportation Research Part A, Vol. 34, pp. 459-479.

Frankel, E. G., ((1997) "The Economics of Total Trans-ocean Supply Chain Management" *International Journal of Maritime Economics: Vol. 1, No. 1, pp61-69*

Gardiner, P. (2009) Fighting Back. Lloyds' Shipping Economist. October 2009, pp.10-13

Gardner, B., Marlow, P. and Nair, R. (2002) The Economic Regulation of Liner Shipping: the Impact of EU Regulations in US Trades, In Grammenos (Ed.) The Handbook of Maritime Economics and Business, LLP London

Groothedde, B., Ruijghrok, C. and Tavasszy, L. (2005) Towards Collaborative, Intermodal Hub Network: a Case Study in the FMCG Market, Transport Research Part E, Vol. 41, pp. 567-583.

Johansson, H., McHugh, P., Pendlebury, A. and Wheeler W. III (1993), Business Process Re-engineering, Wiley, New York, NY.

Kerr-Dineen, P. (2003) The Relationship Between Shipping & World Trade, LRN Conference, London

Kerr, L. (2009) World Fleet Changes, September 2009. Containerisation Int. Nov. 2009, pp. 23-25

Lagoudis, I., Naim, M. and Potter, A. (2010) Strategic Flexibility Choices in Ocean Transportation Industry International Journal of Shipping and Transport Logistics. Vol. 2, No. 2, pp.187-205

Morlok, E. K. and Chang, D. J., 2004, Measuring Capacity Flexibility of a Transportation System, Transportation Research, Part A, Vol. 38, pp. 405-420.

Naim, M., Potter, A., Mason, R. and Bateman, N. (2006) The Role of Transport Flexibility in Logistics Provision, International Journal of Logistics Management, Vol. 17, pp.297-311

Peppers, D. and Rogers, M., 1997, Enterprise One-to-one: Tools for Building Unbreakable Customer Relationships in the Interactive Age, Piatkus, London.

Sanchez, A. and Perez, M. (2005) Supply Chain Flexibility and Firm Performance: a Conceptual Model and Empirical Study in the Automotive Industry, International journal of Operations and Production management, Vol. 25, pp.681-700

Stevenson, M. and Spring, M. (2007) Flexibility from a Supply Chain Perspective: Definition and Review, International Journal of Operations and Production Management, Vol. 27, pp.685-713

UNCTAD (2008) Review of Maritime Transport. United Nations, Geneva

WSC (World Shipping Council) (2010) Economic Contribution of Liner Shipping Industry http://www.worldshipping.org/benefits-of-liner-shipping/global-economic-engine accessed on 11/05/10

SECTION 10 – Reverse Logistics

INVESTIGATION OF THE EXTENT OF REVERSE LOGISTICS MANAGEMENT IN MALAYSIAN AUTOMOTIVE INDUSTRIES

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ABSTRACT
The research looks at the level of implementation of reverse logistics management by Malaysian automotive companies. The study developed a score sheet which was distributed to supply chain managers in the automobile companies, their suppliers and customers. Based on the score sheet, an assessment was carried out on the level of implementation of reverse logistics management based on some measures and metrics. The result was used to derive inferences and conclusions. The study revealed that reverse logistics management in the automobile industry in Malaysia has not received the necessary attention.

INTRODUCTION
The manufacturing industries through their product and processes have been identified as one of the major sources of environmental degradation in the world today (Solvang et al, 2006; Gonzalez-Torre and Adenso-Diaz, 2006; Azzone and Noci, 1998). These revelations have resulted in these industries witnessing tremendous pressure from regulatory bodies to imbibe the culture of environmentally responsible practices (Gonzalez-Torre and Adenso-Diaz, 2006). It was further pointed out that the direct key drivers towards this environmental responsible practices also includes societal and customer pressures, thus the strive for good corporate image (van Hoek, 1999, Gonzalez-Torre and Adenso-Diaz, 2006). The automotive industry has received a fair share of these regulations in different parts of the globe (ECE, 2000; EPA, 2000; Schultmann et al, 2006; von Ashen, 2006; Cruz-Rivera and Ertel, 2009). Many organizations have resorted to green supply chain management (GSCM) to cope with these regulations. This will involve the integration of environmental consideration into supply chain management, thus green purchasing, green material management and manufacturing, green distribution and marketing, and reverse logistics (Hervani et al, 2005; Zhu and Sarki, 2006). Vachon and Klassen (2008), further buttress the fact that suppliers, manufacturers and customers should work together towards the reduction of environmental impact from production processes and the ensuing products. Therefore, for a complete GSCM in the automotive industry, there is need for an efficient and effective reverse logistics management.

REVERSE LOGISTICS MANAGEMENT (RLM)
Reverse logistics has been defined as the process of planning, operations and controls of the flow of logistics information and the corresponding return of post sale and post-consumption goods to the productive cycle through reverse distribution channels (Leite, 2003; Nunes et al, 2009). Pokharel and Mutha (2009) and Nunes et al (2009) asserted that the focus of reverse logistics is on waste management, material recovery through recycling, and part or product recovery through remanufacturing, refurbishment and reuse. Thus, reverse logistics in the automotive industry involves the process of planning, implementing, and controlling the efficient flow of end-of-life vehicles (ELVs) from the point of use (customer) through the process of remanufacturing, refurbishment, reuse and recycling, aimed at recapturing value as well as proper waste disposal (Autry, 2005; Olugu et al, 2010).

Benefits of RLM

Several benefits have been identified as the core reasons why organizations practice reverse logistics management. An efficient and effective reverse logistics management has been identified as value adding by aiding the fulfilment of regulatory requirements, as well as boosting organizational corporate images and improvement on raw materials savings and landfills related issues (Autry, 2005; Nunes et al, 2009). Increase in the cost associated with disposal of waste and acquisition of landfills have lead manufacturing organizations to intensified efforts at exploring economically viable alternatives such as reverse logistics(Autry, 2005; Nunes et al, 2009).

Iligin and Gupta (2010) observed that an effective management of reverse logistics operations will result in higher profits through reduction in transportation, inventory and warehousing costs. Efficient reverse logistics operations are believed to yield a significant return on investment as well as a significantly increased competitiveness in the industry (Efendigil et al, 2008; Newman and Hanna, 1996). It has further been highlighted that reverse logistics operations influence forward logistics activities in the aspect of creation of storage space and transportation capacity. There is an observation that reverse logistics is very instrumental towards achieving a green supply chain (Efendigil et al, 2008; Olugu et al, 2010, Schultmann et al, 2006).

It has been posited that recycling utilizes less energy and produces less pollution compared to from zero manufacturing (ISWA, 2009). The study further stated that significant CO_2 emission reductions can be achieved through appropriate solid waste management process such as reverse logistics. Thus, investments in waste management can lead to net emission savings of up to 20% (ISWA, 2009).

The automobile reverse logistics

Reverse logistics in practice begins with the customer. There are at least 4 possibilities after the customer has derived maximum satisfaction from a vehicle. A customer might decide to sell the vehicle directly to another user or to dealers who sell it locally or export it to other users elsewhere. The second possibility involves the customer doing a trade-in with the dealer or distributor for a new vehicle. The third possibility is that the vehicle is returned to a collection center after its useful life to the owner, from where the vehicle is prepared for recycling. The final possibility is that the vehicle ends up with some collectors, who keep it in a museum or show place. In this study, the third possibility is regarded as the ideal, as all the other two still get to follow the third possibility or scenario. In contrast, the fourth is not inclusive, except when the vehicles are finally disposed. Also, the vehicles that end up in collectors/museums are very infinitesimal, making their exception in the analysis justifiable.

THE AUTOMOTIVE INDUSTRY IN MALAYSIA

In Malaysia today, the automotive industry is one of the backbones of the economy through its various activities such direct manufacturing, assembling and component manufacturing (Rosli, 2006). Some of these products are exported to countries such as Pakistan, Brunei, Singapore, Myanmar, Indonesia, etc. The automobile industry in Malaysia has been around for over 50 years (MAA, 2008) and has grown from being a mere assembler of passenger and commercial vehicles to a manufacturer. Currently, there exist over 2 dozens of automobile manufacturing and assembly plants producing passenger and commercial vehicles, composite body sports cars as well as motorcycles and scooters (MIDA, 2006). Their capacity approximates a million passenger and commercial vehicles, and a million motorcycles per year (MAA, 2008). Some of the automotive in companies in Malaysia includes Perusahaan Otomobil Nasional (PROTON), Perusahaan Otomobil Kedua (PERODUA), Industri Otomotif Komersial (INOKOM), and Malaysian Truck and Bus (MTB). Others include NAZA Automotive assembling, Asian Automobile Industries, Oriental Assemblers, Tan Chong Motor Assemblies and Swedish Motor Assemblies etc. PROTON and PERODUA are the largest car manufacturers in the country. The two jointly boast of over 75% of the total number of passenger vehicles in Malaysia over the past few years (MIDA, 2006).

REVERSE LOGISTICS MEASURES AND METRICS

In these study a set of measures and metrics were used to evaluate the level of reverse logistic management in Malaysian automotive industries. These measures and their corresponding metrics which forms the basis for this assessment is presented in Table 1. These measures and metrics are divided into 2 which are internal and external as adopted from Olugu et al, (2009). The internal measures are used to evaluate operations which are carried out within the company, while the external ones are for operations extrinsic to the company.

	Measures	Metrics
Internal	Recycling efficiency	i. Percentage decrease in recycling time ii. Availability of recycling standards iii. Availability of standard operating procedures, iv. Percentage decrease in utility usage during recycling v. Efficiency of shredders and dismantlers vi. Percentage reduction in emission and waste generated.
	Recycling cost	i. Cost associated with returning ELVs, ii. Cost associated with processing recyclables, iii. Cost of sorting and segregating recyclables iv. Cost of disposing hazardous and unprocessed waste.
	Management commitment	i. Level of motivation to customers on returning their ELVs ii. Availability of standard operating procedures ELVs collection iii. Availability of collection centers for ELVs iv. Availability of waste management schemes.
	Material features	i. Level of waste generated ii. Ratio of recycled materials to recyclable materials iii. Material recovery time.
External	Customer involvement	i. Level of customer cooperation in returning their ELVs ii. Level of customer-to-customer dissemination of information iii. Level of understanding of the greening process by customers.
	Supplier commitment	i. Extent of return delivery from suppliers to manufacturers ii. Certification system for suppliers iii. Number of supplier initiatives in reverse logistics.

Table 1: Measures for RLM in automotive industry

RESEARCH METHODOLOGY

In this study, 3 sets of assessment score sheets were developed using the measures and metrics listed in Table 1. Each of these score sheets was used for the evaluation of the internal and external operation of the RLM in the automotive industry. The external aspect was further separated into two, one for the suppliers and the other for the customers. A 3-point likert scale represented as poor, fair and good was used to assess the metrics for each measure. Each of these categories was further subdivided into 3 different classes. For poor, the classes were 1 for highly poor, 2 for moderately poor and 3 for lowly poor. For fair, another 3 classes were defined which were 4 for lowly fair, 5 for moderately fair and 6 for highly fair. The last 3 categories were 7 for lowly good, 8 for moderately good and 9 for highly good. After the development of this scale, an appendix was developed which explained the score allocation criteria for each of the metrics. The score sheets were then sent to 10 experts in the field of automobile reverse logistics and green supply chain management to verify their inclusiveness and ease of understanding. The comments given were implemented and modifications were made accordingly.

Two major automobile companies in Malaysia were selected based on their market shares to represent the Malaysian automobile industry. These two control a market share of more than 75% of passenger vehicles in Malaysia. Based on this, the 2 companies signify a good representative sample for investigation. 50 customers each were selected to assess the customer involvement in the reverse logistics of these companies. In addition, 5 persons who are experts in the area of logistics were selected to assess the practices in their respective organizations using the score sheet. The measures in Table 1 were used in conducting the evaluation. The same was done on all the selected suppliers of the 2 companies. The suppliers for the two companies were also assessed by 5 experts in their own organizations.

The study witnessed a 100% response rate as all the evaluation was conducted as a guided assessment in the presence of the evaluators. All the evaluators were met in person and they were very eager to assist in the evaluation. The only area that witnessed less than 100% response was the aspect of the customers. This was basically because some customers declined the assessment due to inadequate knowledge about reverse logistics in automobile industry. The results involved the summation of the score for each metrics to see how that metric has faired in the assessment.

RESULTS AND DISCUSSIONS

The first set of results is presented in Figure 1. This involved the internal measures such as recycling cost, management commitment, material features and recycling efficiency. The other set of result involved the external measures such as supplier commitment and the customer involvement as presented in Figure 2.

From the first, it was found that for recycling cost: the cost associated with returning of ELVs (CARE) had an average score of 6.31, cost associated with sorting and segregation of recyclables (CSSR) – 3.2, cost of disposal of hazardous and unprocessed waste (CDHW) – 2.1, and the cost associated with processing of recyclables (CAPR) – 4.81. From the result it can be seen that CARE had a considerable average score. This is mainly due to the cost incurred from the rebate given to customers for the returning of their ELVs. The rebate is aimed at providing the customers with minimum deposit for a new vehicle. The other 3 metrics such as CSSR, CAPR, and CDHW showed a very low average score. This is not unexpected as the recycling process in Malaysian automotive industry is still an under-tapped area. This is in line with Amelia et al (2009), that no record exist of recycled new vehicles in the Malaysian automobile industry

In terms of management commitment, availability of collection centers (ACC) and the level of motivation to customers on ELVS (LMCE) scored highest with 5.7 and 5.6 respectively. These relatively high score is mainly because of the license plate cancellation scheme by the government and also the rebate by manufacturers to customer on their purchase of new vehicles after they have given out their ELVs. The other results are availability of standard operating procedure for collection of ELVs (ASOPCE) - 4.8 and finally, availability of waste management scheme (AWMS) – 3.3. The government initiative on ELVs is responsible for the considerable score on ASOPCE. Lastly, the AWMS scored lowest to show that waste management still requires much attention.

In terms of the material features, level of waste generated (LWG) scored considerably high with an average score of 8.6. This is mainly due to the availability of market for used spare parts. Ratio of materials recycled to recyclable material (RMRRM) scored low – 2.4. This goes to further buttress that the recycling of ELVs is yet to get the necessary attention in

Malaysia. Material recovery time (MRT), showed a low score of 2.6. This also mainly because there is no standard recycling plant for these ELVs in Malaysia.

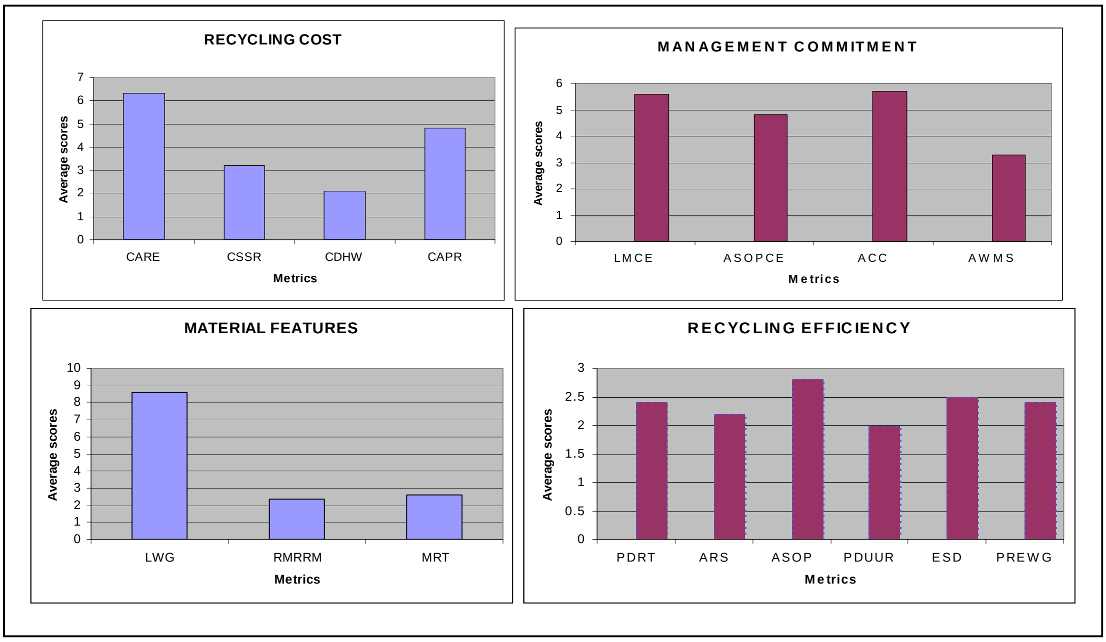

Figure 3: Results of the internal measures

For recycling efficiency, all the measures scored considerably low. Percentage decrease in recycling time (PDRT) – 2.4, availability of recycling standards (ARS) – 2.21, availability of standard operating procedures (ASOP) – 2.81, percentage decrease in utility usage during recycling (PDUUR) – 2, efficiency of shredders and dismantlers (ESD) – 2.4, and finally, percentage reduction in emission and waste generated (PREWG) – 2.24. As mentioned earlier, these low score is attributed to the lack of recycling plants for these ELVs. So there are virtually no good records of practices in these metric areas.

In this section, the external measures are considered such as supplier commitment and customer involvement as presented in Figure 2. Under customer involvement, level of customer cooperation in returning ELVs (LCCRE) had a relatively high average score of 5.37, compared to level of customer-to-customer dissemination of information (LCDI) – 3.29 and level of understanding of green process by customers (LUGP) – 2.42. The relative high score for LCCRE can be attributed to the incentive given by the companies for their ELVs. Thus, the customers seem to be goaded by that gesture. On the other hand, the relatively low values for LCDI and LUGP can be attributed to the poor awareness of the customers about reverse logistics. This was also evident in the number of customers who turned down the survey due to lack of knowledge.

For supplier commitment, the extent of delivery from supplier back to manufacturer (EDSM) scored the least of the three metrics with an average score of 1.12. This is expected as there is no formal reverse logistic process in these companies. Certification system for suppliers (CSS) also scored low with an average of 2.67. This can also be attributed to the fact that the suppliers do not have a strong reverse logistics commitment. Finally, the number of supplier initiatives in recycling process (NSIRP) which had an average score of 2.73. This low score also goes to buttress the fact that the suppliers are not committed to the reverse logistics practice.

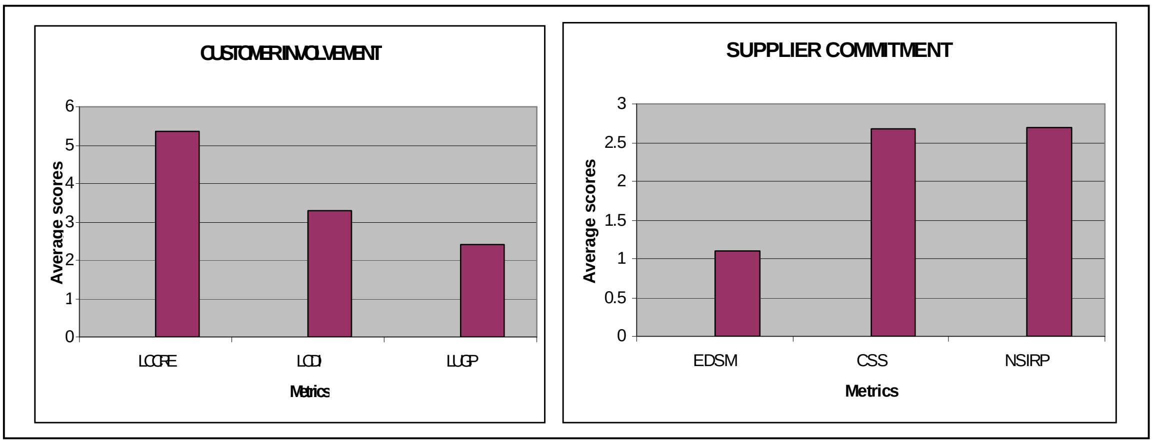

Figure 4: Results of the external measures

From the foregoing results, it can be observed that reverse logistics practices amongst Malaysian automobile companies is yet to receive adequate attention. This trend can be turned around, if the government will come up policies that will monitor and encourage these processes. This will in turn ease off the over reliant on totally new component and create a balance on the industrial eco-system (Solvang et al, 2006). It has been posited that recycling uses less energy than manufacturing product from scratch (ISWA, 2009). Thus, recycling and reverse logistics in general will reduce energy consumption and the ensuing emission. It will also reduce saturation being witnessed by the used spare part market. Finally, if the reverse logistics process is well harnessed, it will yield economical dividends (Autry, 2005; Nunes et al, 2009).

CONCLUSIONS AND RECOMMENDATIONS

The study has looked at the level of reverse logistics management practices in the Malaysian automotive industry. In order to carry out this investigation, 6 measures and their corresponding metrics were adopted. Assessment was conducted using 2 selected major automobile manufacturers in Malaysia, their customers and suppliers. A score sheet was used to guide the assessors in the evaluation exercise. From the result obtained, it was found that reverse logistics management practice by Malaysian automobile manufacturers have not received the necessary attention. It is recommended that further study should be conducted which will be aim at evaluating the extent of reverse logistics practices in the other manufacturing sector of the economy. Secondly, a cross-country and inter-sectarian investigation should be conducted to reveal the extent of these practices in the South-East Asian region

REFERENCES

Amelia, L, Wahab, D.A, Che Haron, C.H., Muhamad H, Azhari, C.H (2009), "Initiating automotive component reuse in Malaysia" Journal of Cleaner Production Vol.17,No. 17,pp.1572–1579.

Autry, C.W. (2005) "Formalization of reverse logistics programs: a strategy for managing liberalized returns" *Industrial and Marketing Management, Vol. 34*, No.1,pp. 749-757.

Azzone, G., and Noci, G. (1998)"Seeing ecology and green innovations as a source of chance" Journal of Organizational Change Management, Vol.11, No.2, 94–111.

Cruz-Rivera, R. and Ertel, J. (2009) "Reverse logistics network design for the collection of end-of-life vehicles in Mexico" European Journal of Operational Research, Vol. 196,No.3, pp. 930-939.

ECE, (2000) "Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on End-of-Life Vehicles" Official Journal of the European Communities, L269, pp.34-42.

Efendigil T, Onut S., Kongar E. (2008) "A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness" Computers and Industrial Engineering, Vol.54, No.1, pp.269–287.

EPA, (2000) "Strategies for Waste Reduction" EPA-530-F-00-001, Available at: http://www.epa.gov/osw (accessed 10.12.2009).

Gonzalez-Torre, P.L. and Adenso-Diaz, B. (2006) "Reverse logistics practices in the glass sector in Spain and Belgium" International Business Review, Vol.15., No.1, pp.527–546.

Hervani, A.A., Helms, M.M. and Sarkis, J. (2005) "Performance measurement for green supply chain management" Benchmarking: An International Journal, Vol.12, No. 4, pp. 330-353.

Ilgin, M. A., and Gupta S.M (2010) "Environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art" Journal of Environmental Management, Vol. 91 No. 3, pp. 563-591.

ISWA, (2009) "International Solid Waste Association, Position on R1 and D10 Criteria in the EU waste framework directive" available at www.iswa.org, (accessed on 10.12.2009)

Leite, P.R. (2003) "Reverse Logistics" Prentice Hall, Sao Paulo.

MAA, (2008) "Malaysian Automotive Association, Summary of sales and production data" available at www.maa.org.my/info_summary.htm. (accessed on 3.01.2010)

MIDA (2006) "The Automotive Industry in Malaysia, The Malaysian Industrial Development Authority" available at www.mida.gov.my (accessed on 05.01.2010)

Newman, W. R. Hanna, M. D. (1996) "An empirical exploration of the relationships between manufacturing strategy and environmental management" International Journal of Operations and Production Management, Vol. 16,No. 4,pp. 69-87.

Nunes, K.R.A, Mahler, C.F and Valle, R.A. (2009) "Reverse logistics in the Brazilian construction industry" Journal of Environmental Management, Vol. 90, No.1, pp. 3717-3720.

Olugu, E.U, Wong K.Y and Shaharoun, A.M. (2009), "Proposed Performance Measurement Areas for an Automobile Green Supply Chain", paper presented at the 13th IBIMA Conference on Knowledge Management and Innovation in Advancing Economies, Marrakech, Morocco.

Olugu E.U., Wong, K.Y., Shaharoun, A.M. (2010) "A comprehensive approach in assessing the performance of an automobile closed-loop supply chain" Sustainability, Vol. 2, 2010, in press.

Pokharel, S. and Mutha, A. (2009) "Perspectives in reverse logistics: A review" Resources, Conservation and Recycling, Vol. 53 No. 4, 175-182.

Rosli M. (2006) "The automobile industry and the performance of Malaysian auto production" Journal of Economics Cooperation, 27(1): 89-114.

Schultmann F., Zumkeller M., Rentz O. (2006) "Modeling reverse logistic tasks within closed-loop supply chains: An example from the automotive industry" European Journal of Operational Research, Vol.171, pp.1033–1050.

Solvang, W.D., Roman, E., Deng, Z. and Solvang, B. (2006) "A framework for holistic greening of value chains" International Federation for Information Processing (IFIP), Knowledge Enterprise: Intelligent Strategies in Product Design, Manufacturing, and Management, Vol.207; 350-355.

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, pp.795-821.

van Hoek, R. I. (1999) "From reversed logistics to green supply chains. Supply Chain Management" Vol.4, No.3, pp.129–135.

von Ahsen A.(2006) "Environmental management in automotive supply chains: an empirical analysis" In *Greening the Supply Chain*, Sarki J. Ed.; Springer-verlag, London, United Kingdom, pp.293-306.

Zhu, Q. Sarkis, J. (2006) "An inter-sectoral comparison of green supply chain management in China: Drivers and practices" Journal of Cleaner Production, Vol.14, 472-486.

EFFECTIVE E-WASTE MANAGEMENT: THE ROLE OF INTERNATIONAL COOPERATION AND FRAGMENTATION

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ABSTRACT

E-waste problems related to trade in wastes and informal recycling in the developing countries address environmental, social, and economic effects. Moreover, given on multiple aspect considerations, it is found that currently recycling fragmentation trade presents. This paper first reviews the driving forces of international trade in wastes and characters fragmentation in recycling industry. In the premise that environments and economic/social benefits can be exchanged among countries, we offer managerial conditions on international cooperation solution that increases e-waste treatment cooperation and fragmentation and contributes to effective e-waste management.

Keywords: e-waste management, recycling fragmentation trade, international cooperation importing countries, exporting countries, environment

INTRODUCTION

The primary issues related to e-waste problem (wastes of electrical and electronic equipments, WEEE) arise from not both quantities and hazardous and toxic materials. Additionally, recycling a huge amount of electronic disposals results in environmental injustice and transnational pollutions as considerable quantities of wastes are not recycled domestically but rather shipped to developing counties, in which inappropriate and informal recycling causes severe damages to environments and human health (BAN and SVTC, 2002; Widmer et al., 2005). Apart from economic aspect, current pollution effect on e-waste is global and not local which calls for cooperative endeavours on managing e-waste crisis. Thus, different policies and initiatives appear to be designed and implemented at both national and global levels, which are including: EPR policy, WEEE in Europe, RoHS in Europe, the Basel Convention, Basel Ban and StEP initiative. However, evidence shows that existing policies directions will mitigate but not solve problems of legal and/or illegal transboundary movement of wastes, informal recycling in industrializing countries, and a global perspective on e-waste management and sustainable development (BAN, 2007; Kahhat and Williams, 2009; Widmer et al., 2005; Williams et al., 2008).

The objective of current cooperative implementation endeavour at international level is to let parties reach their commitment to minimize waste generations and manage wastes within their borders. Unfortunately, the fact is that both developed and developing counties fails to fulfil the restrictions and enforce or implement proper environmental standards due to economic and social considerations. For exporting countries, recycling companies and traders intend to transfer environmental externalities based on cost difference consideration. On the other hand, most importing countries allow waste trade because recycling is viewed as a business opportunity of providing cheaper secondary materials and employment for the poor communities. Even environmental concerns have spilled over into the trade; both exporting and receiving countries currently try to obtain positive effects of trade and put less attention on the externalities of trade. It is found that rationale and approaches behind existing cooperative mechanisms are not working effectively.

As we know, legal/illegal trade in wastes continue to this day. Interestingly, trends and patterns in waste trade have changed. In the past, most used EEE products are shipped from the developed countries to the developing countries. This is generally a port-to-port trade in nature. Recently, given on multiple considerations, it is found that a treatment fragmentation phenomenon appears in recycling industry — cross-border dispersion of e- waste treatments, with each country specializing in a particular stage of the processing sequence based on its own regulations and specific needs (Athukorala and Yamashita, 2006; Yi, 2003). There is a clear example of Peru: the main purpose of imports of used PCs in Peru is basically reuse oriented. If these importing end-of-life equipments are identified not worth reselling or refurbishing, they will be dismantled into different parts and materials which are recycled domestically or exported to China and/or Europe (Kahhat and Williams, 2009). Such changing trends and patterns in waste trade are also among East Asia countries, particularly between Japan and China. The wastes of materials and components generated in Japan export to weaker economies for recovering recyclable resources, which provide local manufacturers in the receiving countries and Japan cheaper secondary materials (Zeng and Zeng, 2007).

International vertical specialization in manufacturing industries is well known, but waste fragmentation trade, reflected mainly in the trade in parts and materials of e-waste, is new form of trade in wastes and is less known than the conventional trade in final obsolete EEE products. Many questions arise within the presence of e-waste treatment specialization. What is the character of fragmentation trade of e-waste? Are recycling networks leading to any benefits and impacts for both importing countries and exporting countries? Is studying such new form of e-waste recycling system beneficial in providing more information about environmental and economic implications of different choices?

Based on the discussion above, the context we wish deal with is the following. Considering a situation that each of countries faces a waste trade constraint in the form of conditional utility trade-off between economic/social and environmental aspects, in which exporting/importing pollution-intensive products have an incentive to reach minimizing environmental effects and maximizing economic/social effects at the lowest possible cost. Our first aim is then to characterize the driving forces of international trade in wastes and the presence of recycling fragmentation trade, and check if cooperative solutions for waste trade may help resolve some or all of e-waste problems. Secondly, this paper explore that given what kind of cooperative conditions of driving forces, fragmentation trade in e-waste behave strategically to facilitate the solutions to problems.

In the next section, this paper will character the driving forces of international trade in wastes and the presence of e-waste fragmentation trade by drawing on insights from recent research on WEEE recycling and management. We also review relevance studies and outline benefits and effects of recycling fragmentation within both importing countries and exporting countries. The following is that we provide views on conditions in the context of embedding international cooperation solution in e-waste treatment fragmentation, which may contribute to effective e-waste management. The discussion and concluding remark are included.

REVIEW OF PAST STUDIES

In this section, we review of past studies from various categories: e-waste generation and flows, driving forces of international trade in wastes, and recycling fragmentation trade.

E-waste generation and flows

Rapid leap in information technology and innovation is expected to lead to e-waste generation at an alarming rate of obsolesce. It was estimated that 2 million tonnes of e-waste generated in the Unites States in 2000, and the overall e-waste volume was estimated at 5 to 7 million tonnes and are likely increasing by 3% to 5% per year. Due to lake of standard categories and definitions of e-waste and difference of take-back legislations among countries, the data and figures are not reliable but are projected to be higher today and rapidly increasing (BAN and SVTC, 2002; Terazono et al., 2006). Managing increasing quantities of used EEE appliances poses a challenge to policymakers. Table 1 presents the estimated amount of e-waste and its categories in selected countries.

Country	**E-waste generated (tonnes/year)**	**Categories of e-waste**	**Year**
Switzerland	66042	Office & telecommunications equipments, consumer entertainment equipments, large and small domestic appliance, refrigerators, fractions	2003
Germany	1100000	Office & telecommunications equipments, consumer entertainment equipments, large and small domestic appliance, refrigerators, fractions	2005
UK	915000	Office & telecommunications equipments, consumer entertainment equipments, large and small domestic appliance, refrigerators, fractions	1998
Denmark	118000	Electronic and electrical appliances including refrigerators	1997
USA	2158490	Video products, audio products, computers and telecommunication equipments	2000
Canada	67000	Computer equipments, consumer electronics	2005
Taiwan	14036	Computers, home electrical appliances	2003
Thailand	60000	Refrigerators, air conditions, TVs, washing machines, computers	2003

Table 1 Estimated e-waste volume and categories in the selected countries.
Source: Terazono et al. (2006)

Figure 1 is used to indicate main e-waste flows in Asia; however, no reliable data and figures available on how these transboundary e-waste routes are because currently the illegal and unregulated sector dominates the recycling industry in the industrializing countries (Widmer et al., 2005). As such, there are many obstacles revealed in safely and effectively processing electronic disposals.

Figure 1 The routes of e-waste in Asia
Source: Widmer et al. (2005)

Driving forces of international trade in wastes

Drawing upon literature, there are three driving forces of cross-border movement of wastes identified as follows: legal and policy, economic value, and social consideration. The three categories above may have individual significant influence on current e-waste management and sometimes they may act as dynamic and interacted effects.

The first key factor is legislations and regulations which contribute to legal/illegal waste trade. According to research by Yoshida and Kojima (2008), inconsistency of environmental standard and waste definition among countries leads to free-rider problems and failures of controls on trade. From a legal standpoint, however, due to lack of relative legislations and/or lax of enforcement, it is possible for countries to manage end-of-life electronic goods cross their borders (Hicks et al., 2005; Widmer et al., 2005; Yang et al., 2008). For example, electronic disposal may be exported in the names of mixed metal scraps and other components if they can be used as raw materials; the exports of recyclable wastes and secondary goods which may contain hazardous substances and materials are recycled and cause pollutions in receiving countries at the end of products' usages (BAN and SVTC, 2002; Yoshida and Kojima, 2008). Moreover, in response to highly environmental awareness and highly stringent regulations, recyclers may in turn export wastes for easy solutions for waste treatment because of increasing treatment costs and facilities investments. Recycling plastics in Japan is a good example for illustrating how some countries use legal exemption to transfer the externalities of costs to weaker economies (Zeng and Zeng, 2007).

Economic value is also expected to contribute to trade in wastes. There are many examples as follows: (1) for recyclers in the exporting countries, due to higher recycling costs raised from higher labour and investments on treatments and facilities, the adoption of exporting wastes is an effective management to lead to the economic benefits of comparative advantage; (2) evidence shows that some obsolete but functional EEE equipments are viewed as "wastes" in developed countries, but they are sold as "new" products in developing countries after repairing and refurbishing. The highly monetary margin is driving to waste trade (Stricher-Porte and Yang, 2007); (3) depending on value of scraps, wastes may be recycled locally for valuables and remaining less- or non-valuable materials/components are exported to other countries for further processing and landfills (Terazono et al., 2006; 2007); and (4) the growing demand for recyclable resources is also an essential contributor to encourage growing trade in recyclable wastes (Hicks et al., 2005).

Thirdly, for many developing countries, imports of secondary electronics/e-wastes benefit in helping the poor, solving digital divide problem and providing cheaper EEE products, which reveals social benefits of trade in wastes (Widmer et al., 2005). Many importing countries view "recycling" as a business opportunity which provides huge employments for poor communities. Peru imports an increasing number of used computers from US over time and the major purpose of imports is oriented toward reuse as opposed to recycling (Kahhat and Williams, 2009). In the industrializing countries such as China and India, the majority of imports of used IT appliances can be sold as second-hand or new goods after repairing or refurbishing activities. The poor in the industrializing countries can own IT products at the lower costs than in the developed countries (Li et al., 2006; Yang et al., 2008).

Recycling fragmentation trade

The driving forces above may result in that the obsolete EEE products are traded among not only two single destinations but also multiple destinations. Moreover, some other variables such as technology and complexities of EEE equipments also influence the routes of end-of-life electronic goods, resulting in the phenomenon of recycling fragmentation trade, in which used EEE products are treated in multiple and sequential stages and two or more countries provide value added in the waste's processing sequence. Figure 2 indicates the patterns of recycling fragmentation trade in different countries and each stage provides value added in the recycling sequence to gain revenues. In sum, regardless of what kind of considerations, inputs may need to cross multiple borders in order to gain environmental and/or finance profit benefits within a trade provision case.

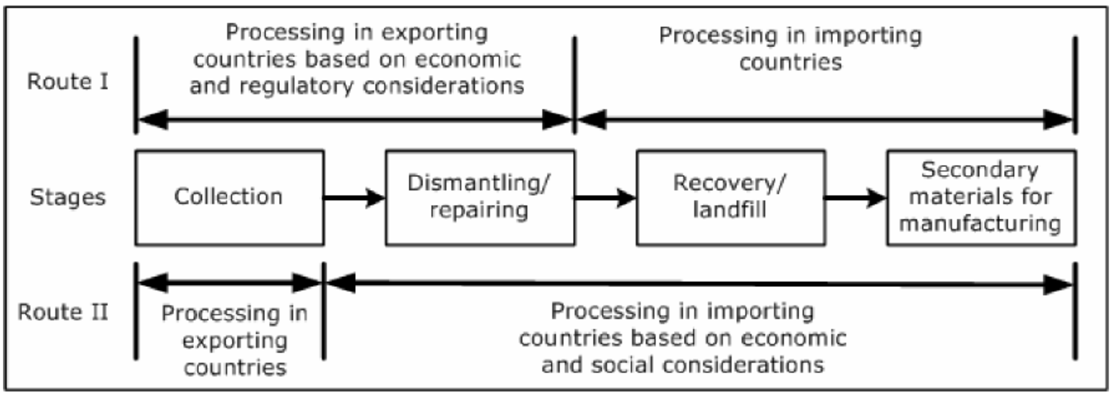

Figure 2 The patterns of recycling fragmentation trade

Because WEEE contains many hazardous and toxic substances and materials, which may cause serious air, water and soil pollution, as well as damage to human health if improperly handed. Therefore, while companies in recycling industry may reach global economic efficiency through fragmentation option, the environmental externalities have spilled over into the issues of trade in wastes. This paper is intended to neither discuss this controversial issue nor provide a conclusive suggestion for the best solution. In contrast, we aim to explore the presence of e-waste recycling fragmentation and provide views on the other possibilities of alternative practices on WEEE management. Table 2 presents the positive and negative effects on recycling fragmentation in both exporting and importing countries, which enables the multidimensionality of problems and policies to be taken into account and is beneficial in developing feasible and effective of implementation. After all, current research provides too little about environmental and economic implications of different choices (Williams, 2005).

	Exporting countries	**Importing countries**
Positive benefits	• Minimizing amounts of wastes recycled domestically • Minimizing pollutions • Increasing financial profits	• Providing cheaper secondary products, components and materials • Generating job opportunities • Solving digital divide • Promoting recycling industrial scaling-up and technology advancement
Negative effects	• Causing environmental injustice when exporting hazardous and non-recyclable wastes • Facing obstacles of changing regulations in importing	• Increasing environmental and human health risks
Negative effects for both countries	• Increasing illegal trade • Increasing difficulties on monitoring and controlling trade • Increasing illegal storage and dumping when hard to recycle possible cheaper costs	

Table 2 Positive and negative effects of recycling fragmentation trade

DISCUSSION AND PROPOSITIONS

We consider WEEE management with regulatory, environmental, economic, social and technology aspects, formulating our propositions in which given what kind of cooperative conditions of driving forces, recycling fragmentation trade behave strategically to facilitate the solutions to e-waste problems. Since environmental concerns have spilled over into the trade negotiation process, the terms of trade taxes, tariffs and subsidies in the economics analysis are incorporated into cooperative plans and implementations (Cassing and Kuhn, 2003; Copeland, 2000). Inspired by the literature on cooperation game and fragmentation (Athukorala and Yamashita, 2006; Lejano and Davos, 1999), three scenarios are considered and will be defined rigorously later on: (1) *single country scenario:* each country chooses its waste amount and recycling instruments so as to optimize its own welfares without facing an environmental constraint; (2) *multiple destinations in two single countries scenario:* each play's optimization is as in the previous scenario. In this setting, countries may incorporate restriction on environmental policy into trade agreements and seek equality associated with cost and/or benefit allocation based on the bilateral cooperative mechanism; and (3) *multiple countries scenario:* cooperative setting and framework among multiple countries is as in the previous scenario but each stakeholder can however make collective decision on fairness rather than decide on a personally optimization.

As mentioned, inconsistency of environmental standard and waste and second-hand product definitions among countries dramatically leads to free-rider problems and failures of controls on trade. If the fairness of distribution of costs and benefits is possibly achieved by the cooperative mechanism among countries, countries may have greater willingness to make a collective decision on bilateral and/or multilateral contracts and agreements. As a result, the likelihood of traceability of the traffic and data of wastes will be increased; government agencies can easily control the illegal movement of wastes and guarantee that wastes are recycled with safely and efficient treatment. As such, we present proposition 1 as follows,

Proposition 1: The higher consistency of environmental standards and regulations among countries is decreasing in the illegal trade, increasing in the recycling fragmentation in scenarios 2 and 3, and increasing environmental and profitable strategic purposes on e- waste management.

From economic perspective, we focus on the value of wastes and secondary materials. China becomes the key recyclable resources importer in the world because of growing demand for cheaper secondary materials. The financial profit has strong incentive for dealers to trade wastes without considering environmental externalities and trade barriers, resulting in illegal trade and severe damages to human and environment. If equitable and effective trade agreements subject to cooperation by special interests of each player are developed, this arrangement can force exporting countries internalize environmental effects through tariffs or subsidies while importing countries gain economic and social benefits. We therefore provide proposition 2,

Proposition 2: The greater difference of value of wastes and recyclable resources is increasing in the movement of wastes, increasing in recycling fragmentation scenarios 2 and 3, and increasing in environmental and profitable strategic purposes on e-waste management.

In the case of Peru, multiple purposes of imports of wastes lead to fragment recycling activities into several stages in different countries. Imports of used computers in Peru are mainly used for secondary goods and end up with metal recovery purpose. Furthermore, after the dismantling process recyclers in Peru may process computer parts and materials domestically (e.g., copper cables) or export them to China and Europe (e.g., circuit boards). If arrangements are developed based on optimizing each party's welfare, components and materials may ship to country which provides environmental friendly treatment. As such, recycling fragmentation trade is helping solving e-wastes problems associated with social benefits and pollutions. Such a condition leads to proposition 3.

Proposition 3: The more purposes of wastes and second-hand goods is increasing in the movement of wastes, increasing in recycling fragmentation scenarios 2 and 3, and increasing in social and environmental strategic purposes on e-waste management.

The key driver to fragment recycling activities across borders can be waste treatment technology. As electronic and electrical wastes are diverse and complex, in terms of the type, size, and shape of materials and components, recycling processes and facilities play a critical role in developing a cost-effective and environmental friendly recycling system (Cui and Forssberg, 2003). Besides, when arranging trade-off of benefits and externalities of specialization, increased flows of capital and technology among countries complement recycling sharing, allow firms to extend recycling networks and promote recycling industrial scaling-up in importing countries. Proposition 4 is provided as follows, *Proposition 4: The greater difference of recycling technology is increasing in the movement of wastes, increasing in recycling fragmentation scenarios 1, 2 and 3, and increasing in environmental and profitable strategic purposes on e-waste management.*

CONCLUSION

This paper first reviews the driving forces of international trade in wastes and characters fragmentation in recycling industry. In the premise that environments and economic/social benefits can be exchanged among countries, we offer managerial conditions on international cooperation solution that increases e-waste treatment cooperation and fragmentation and contributes to effective e-waste management.

REFERENCES

Athukorala P. (2006) "Production fragmentation and trade integration: East Asia in a global context", The North American Journal of Economics and Finance, 17, pp.233-256.

BAN AND SVTC (2002) "Exporting harm: the high-tech trashing of Asia", The Basel Action Network and Silicon Valley Toxics Coalition.

BAN (2007) "JPEPA as a step in Japan's greater plan to liberalize hazardous waste trade in Asia", The Basel Action Network.

Cassing J. and Kuhn T. (2003) "Strategic environmental policies when waste products are tradable", Review of International Economics, 11(3), pp.495-511.

Copeland B.R. (2000) "Trade and environment: policy linkages", Environment and Development Economics, 5, pp.405-432.

Cui J. and Forssberg E. (2003) "Mechanical recycling of waste electric and electronic equipment: a review", Journal of Hazardous Materials, B99, pp.243-263.

Hicks C., Dietmar R., and Eugster M. (2005) "The recycling and disposal of electrical and electronic waste in China-legislative and market responses", Environmental Impact Assessment Review, 25, pp. 459-471.

Kahhat R. and Williams E. (2009) "Product or waste? Importation and end-of-life processing of computers in Peru", Environmental Science & Technology, 43(15), pp.6010-6016.

Lejano R.P. and Davos C.A. (1999) "Cooperative solutions for sustainable resource management", Environmental Management, 24(2), pp.167-175.

Nnorom I. and Osibanjo O. (2008) "Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries", Resources, Conservation & Recycling, 52 (6), pp.844–859.

Streicher-Porte M. and Yang J. (2007) "WEEE recycling in China. Present situation and main obstacles for improvement" Paper presented at IEEE International Symposium on Electronics and Environment, Orlando, USA, Available: http://ewasteguide.info/system/files/Streicher_2007_IEEE.pdf.

Terazono A., Murakami S., Abe N., Inanc B., Moriguchi Y., Sakai S., Kojima M., Yoshida A., Li J., Yang J., Wong M.H., Jain A., Kim I.-S., Peralta G.L., Lin C.-C., Mungcharoen T., and Williams e. (2006) "Current status and research on E-waste issues in Asia", Journal of Material Cycles Waste Management, 8, pp.1-12.

Williams E. (2005) "International activities on E-waste and guidelines for future work" Paper presented at Proceedings of the Third Workshop on Material Cycles and Waste Management in Asia, Tsukuba, Japan.

Williams E., Kahhat R., Allenby B., Kavazanjian E., Kim J., and Xu M. (2005) "Environmental, social, and economic implications of global reuse and recycling of personal computers", Environmental Science & Technology, 42(17), pp.6.446-6454.

Widmer R., Oswald-Krapf H., Sinha-Khetriwal D., Schnellmann M., and Böni H. (2005) "Global perspectives on e-waste. Environmental Impact Assessment Review", 25 (5), pp.436–458.

Yang J., Lu B., and Xu C. (2008) "WEEE flow and mitigating measures in China", Waste Management, 28, pp.1589-1597.

Yi K.-M. (2003) "Can vertical specialization explain the growth of world trade?", Journal of Political Economy, 111(1), pp.53-101.

Yoshida A. and Kojima M. (2008) "Transboundary movement of recyclable resources: current management system and practices in Japan", Paper presented at Promoting 3Rs in developing countries: lessons from the Japanese experience, Chiba.

Zeng W.-J. and Zeng J.-H. (2007) "Green golden value chain: exploring formation and lessons of Asian reverse material cycles", Research paper at Market Intelligence & Consulting Institute, presented at http://mic.iii.org.tw/intelligence/reports. (In Chinese)

THE TASK ENVIRONMENT, RESOURCE COMMITMENT, AND REVERSE LOGISTICS PERFORMANCE: EVIDENCE FROM THE TAIWANESE HIGH-TECH SECTOR

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ABSTRACT

Purpose: The purpose of the study was to construct a model in order to understand the empirical effects of the task environment on reverse logistics resource commitment and resulting performance.

Design/methodology/approach: The Taiwanese computer, communication, and consumer electronics (3C) manufacturing and retail industries were investigated by questionnaire administration. Structural equation modelling was employed to model relationships among the latent constructs of the task environment, resource commitment, and environmental and economic performance.

Findings: From 349 valid samples, it was found that the task environment has a positive and significant influence on resource commitment. In turn, resource commitment positively and significantly influences the economic and environmental performance of reverse logistics independently. Additionally, environmental performance significantly and positively influences economic performance.

Research limitations/future research: This study focused specifically on manufacturers and retailers in the Taiwanese 3C industry, thus potentially limiting the generalizability of the conclusions. Further studies may wish to focus on other industries or countries, allowing for future comparability.

Practical implications: The deployment of a firm's reverse logistics resources depends on external environmental change. Firms cannot seclude themselves from the external environment, especially the task environment. Under a climate of rapid changes in technology, industry, and markets, firms have to learn to identify opportunities, detect threats, and seize trends based on their task environment.

Originality/value: In the past, economic and environmental performance have been considered to be inherently in conflict. In stark contrast, this study has shown that it pays to be green. Under a climate of increasingly strict international regulations, governmental legislation, and the increase in consumer environmentalism, firms are advised to reappraise their reverse logistics resource commitments appropriately.

Keywords: Task environment, resource commitment, reverse logistics performance, Taiwanese 3C manufacturers and retailers, environmental performance

1 INTRODUCTION

Effective reverse logistics (RL) management has been variously discussed as driving numerous benefits for firms including being a competitive advantage, a positive profit center, a tool to cut costs, and a tool to improve customer satisfaction (Dekker, Fleischmann, Inderfurth, & Van Wassenhove, 2004; Li & Olorunniwo, 2008; Richey, Genchey, & Daugherty, 2005). In recent years, RL has received increasing attention, with the amount of RL literature growing ever since the concept was first introduced into the academic sphere (Jämsä, 2009). Despite these advances, the availability of holistic theoretical literature on RL is scarce (Dowlatshahi, 2005).

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Firms in the Taiwanese computer, communication, and consumer electronics (3C) industry were adopted as the research samples for this study, with this industry being considered favorable for a study on RL. Firstly, not only is Taiwan a significant international producer of information, electronic, and electrical related products, but the Taiwanese 3C and high technology industries specifically are prominent globally. Furthermore, Taiwan has experienced an especially sharp and steady rise in logistics costs over recent years (Ministry of Economic Affairs Taiwan, 2008). Additionally, due to characteristics inherit to 3C products, including remarkably high rates of turnover and complex repair, recycle, reuse, and resale cycles (Daugherty, Autry, & Ellinger, 2001), RL is central to the operations of 3C companies (Blumberg, 1999; Wu & Chen, 2006).

Theoretically, a firm's RL activities depend on internal factors such as resource commitment (Daugherty, Richey, Genchev, & Chen, 2005), external factors such as stakeholder pressure (Álvarez-Gil, Berrone, Husillos, & Lado, 2007), or a combination thereof (Carter & Ellram, 1998). To date, no research has explored how external factors (such as the task environment) drive internal factors (such as resource commitment) and, consequently, RL performance. The present research was designed to fill this gap by examining the relationships between the task environment, resource commitment, and RL performance.

2 LITERATURE REVIEW

2.1 Reverse logistics

The various definitions of the RL concept that have been put forward in the literature have been extremely heterogeneous (Álvarez-Gil, et al., 2007). However, what such definitions have in common is an emphasis on the processes of planning, implementing, and controlling the movement of products or materials in the opposite direction (that is, from customer to supplier) for the purpose of creating or recapturing value, or for proper disposal (Rogers & Tibben-Lembke, 2001).

In this study, RL performance was defined as two distinct dimensions: economic performance and environmental performance. Regarding economic performance, effectively managed RL can deliver benefits including competitive advantage, better visibility, improved customer satisfaction, and enhanced operational efficiency through improved space utilization, labor planning, and inventory control (Jayaraman & Luo, 2007; Marien, 1998; Rogers & Tibben-Lembke, 2001).

Concerning environmental performance, external environmental effectiveness, firm environmental efficiency, green image, and environmental flexibility have been proposed (Azzone & Noci, 1996). Furthermore, Shuangyu and Kohji (2007) identified key indicators characterizing environmental performance, representing numerical measures that provide key information regarding environmental impact, regulatory compliance, organizational systems, and stakeholder relations (Chinander, 2001; Ilinitch, Soderstrom, & Thomas, 1998; Shuangyu & Kohji, 2007).

2.2 Task environment influences on resource commitment in reverse logistics

A given organization's task environment may include competitors, customers, suppliers, strategic partners, and regulators (Scott & Lane, 2000), and in RL contexts specifically, the four task environment forces of customers, suppliers, competitors, and government agencies have been described as being particularly salient (Carter & Ellram, 1998). Success requires the creation of new products and processes and the implementation of new organizational forms and business models. Firms require dynamic capabilities to adapt to changing environments and maintain competitiveness through enhancing, combining, protecting, and reconfiguring their intangible and tangible assets (Teece, 2007). The task environment may have a direct impact on changes in resource commitment. Despite the existence of this potentially revealing connection, no research has explored the relationship between the task environment and resource commitment in RL. The present work aimed to fill this gap and asserted that the task environment has a positive effect on resource commitment.

H1. The influence of the task environment has a positive effect on resource commitment in reverse logistics.

2.3 Resource commitment impacts on reverse logistics performance

The commitment of RL resources has positive impacts on the achievement of RL program goals, including environmental regulatory compliance, reduced inventory investment, improved profitability, and increased economic performance (Daugherty, et al., 2001; Daugherty, Myers, & Richey, 2002). A well-managed RL program can be a huge cost-driving area for greater profitability and customer satisfaction, as well as a boost to the environment (Jayaraman & Luo, 2007).

H2. Resource commitment is positively associated with economic performance in reverse logistics.

Firms investing heavily in environmental management and green innovation can not only improve overall productivity, minimize production waste, increase corporate green image, develop new markets, and further enhance profitability and competitiveness, but can also prevent environmentalist protests and penalties. Such investments in environmental management will become increasingly important under the escalating trends of popular environmentalism, consumer conscientiousness, and a climate of strict international environmental protection regulations (Chen, 2008; Chen, Lai, & Wen, 2006; Hart, 1995; Shrivastava, 1995). As mentioned previously, RL can be viewed as a manifestation of green innovation.

H3. Resource commitment is positively associated with environmental performance in reverse logistics.

2.4 The effect of environmental performance on economic performance

The negative perspective argues that environmental investment merely introduces costs, including those of opportunity, which end up inevitably reducing profit (Greer & Bruno, 1996; Walley & Whitehead, 1994). In contrast, a more positive perspective argues that a firm's environmental performance is not only a potential source of competitive advantage as it can lead to more efficient processes, improvements in productivity, lower costs of compliance, and the opening up of new market opportunities, but can also have a significant positive relationship with economic performance (Chen, et al., 2006; Galdeano-Gómez, 2008; Russo & Fouts, 1997).

H4. The environmental performance of reverse logistics is positively associated with the economic performance of reverse logistics.

3 METHODOLOGY

3.1 Sampling and data collection

The primary survey variables employed in the questionnaire instrument were sourced from the literature, and most items required modification to be applicable to our research context. Through the conducting of in-depth interviews, an additional source of input for the survey were the insights of five business managers involved in resource commitment. Before the primary study was implemented, the instrument was pretested with 35 samples (10 individuals from the academic, consulting, and business sectors, and a further 25 representatives from the 3C manufacturing and retail industries). The readability and understandability of the instrument was subsequently improved based on the comments and suggestions from these respondents.

The surveys were mailed to the 750 member companies of the *3C Retailer Association of Taiwan* and 450 3C manufacturers. A total of 349 usable responses were received, yielding an overall effective response rate of 29.8%. The analysis of non-response bias was conducted by comparing early and late responders (Armstrong & Overton, 1977). Responses from the last quartile of respondents were compared to responses provided by the first three quartiles. No significant differences were found ($p>0.05$) between the two groups. As such, there was no need to further consider non-response bias.

The 349 respondent companies represented a diverse profile of different size firms. Annual company sales ranged from US $2.5 to $25.23 million dollars with mean sales of US $9.36 million dollars (exchange rate as of December 1, 2009). The number of full-time employees ranged from 9 to 2,100, with the mean number of employees being 297. Respondents were further asked to indicate how many full-time employees were assigned to RL. Responses ranged from 1–412, with an average of 11 employees assigned to RL.

3.2 Measurement development

Four constructs were of central interest: the task environment, resource commitment, environmental performance, and economic performance. Although existing scales were employed in the research, modifications were necessary to adapt the items to a logistics context.

The task environment:
Based on the task environment definitions of Castrogiovanni (1991), Scott (1992), Carter and Ellram (1998), and Scott and Lane (2000), the task environment was defined as the collective set of organizations or groups that impact on goal setting and attainment, and which have the capacity to affect decisions, actions, and outcomes.

Respondents were asked to consider separately government, customers, suppliers, and competitors regarding the level of influence exerted on RL and the handling of returned merchandise within their firms. Firstly, it was asked whether the task environment group had the influence to enforce its expectations, and secondly, whether or not the expectations of the group were considered legitimate by management. A 7-point Likert scale was employed where 1 = "strongly disagree" and 7 = "strongly agree".

Resource commitment:
In RL research specifically, three types of resource commitment have been identified, that is, technological, managerial, and financial (Daugherty, et al., 2005; Richey, et al., 2005). Respondents were asked to indicate their levels of resource commitment in implementing RL and the handling of returned merchandise within their firms as related to these three components: technological, managerial, and financial. Items were measured on a 7-point Likert scale where 1 = "little" and 7 = "substantial".

Environmental performance:
Definitions of environmental performance from Azzone and Noci (1996), Ilinitch, et al. (1998), and Jasch (2000) were adopted in defining environmental performance as environmental regulatory compliance, the limiting of environmental impact beyond compliance (Judge & Douglas, 1998), and corporate green image enhancement (Chen, 2008; Jayaraman & Luo, 2007). Respondents indicated how successful they had been in reaching these environmental RL objectives. Again, a 7-point scale was used (1 = "not at all effective" and 7 = "extremely effective").

Economic performance:
The definitions of Melbin (1995), Rogers and Tibben-Lembke (2001), and Biederman (2006) were considered in defining economic performance inclusive of the operational, financial, and customer satisfaction aspects of RL. There were six items: recovery of assets, cost containment, improved profitability, improved labor productivity, improved customer service, and reduced inventory investment. Respondents indicated their degree of success in

achieving these economic performance RL objectives. Again, a 7-point scale was used (1= "not at all effective" and 7 = "extremely effective").

4 DATA ANALYSIS

4.1 The measurement model

Measurement model analysis was used to refine the measurement scale. In our case, four latent variables were constructed from 16 items. We tested the measurement model by considering individual item reliability, internal consistency, and discriminant validity.

In order to asses construct reliability, each of the task environment, resource commitment, and RL performance constructs were checked for their Cronbach's alpha coefficient values. The alpha for the task environment was 0.84 whereas the alpha coefficient for resource commitment was 0.75. The two performance constructs also exhibited high alphas with environmental performance (0.84) and economic performance (0.92). All four scales were considered reliable since their alpha's were greater than the commonly accepted 0.70 threshold (Nunnally & Bernstein, 1994).

The composite reliability and average variance extracted (AVE) were additionally utilized to examine the internal consistency of each latent construct (Fornell & Larcker, 1981). The composite reliability values for each construct exceeded the threshold value of 0.70 (Nunnally, 1978). AVE values also exceeded the 0.50 threshold (Fornell & Larcker, 1981).

Regarding discriminant validity, Table 1 shows the correlation matrix for the constructs, with the diagonal elements being replaced by the square root of the constructs' AVE. Adequate discriminant validity was demonstrated since these diagonal elements were greater than the off-diagonal elements in the corresponding rows and columns (Hair, Anderson, Tatham, & Black, 2006).

Construct	Mean	SD	η_1	η_2	η_3	ζ_1
(η_1) Resource Commitment	5.23	0.90	0.89			
(η_2) Environmental Performance	5.52	0.92	0.59^{**}	0.91		
(η_3) Economic Performance	5.03	0.93	0.46^{**}	0.60^{**}	0.92	
(ζ_1) Task Environment	5.56	0.77	0.49^{**}	0.49^{**}	0.48^{**}	0.93

Table 1: Descriptive Statistics and Correlations

Note: 349 observations, ** $p < .01$, SD: Standard deviation

The values on the diagonal are the square root of the average variance extracted

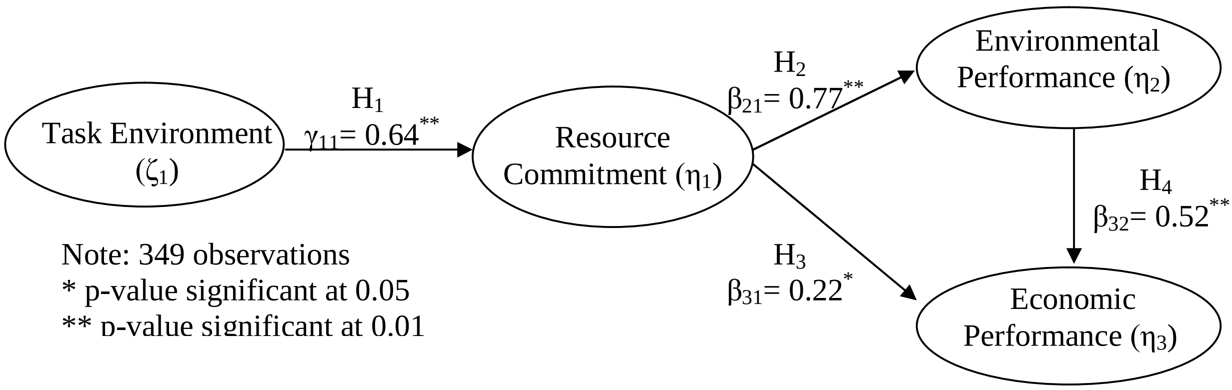

Figure 1. Overall fit of the proposed model and path analysis of the latent constructs

4.2 The structural model

The results of the structural model are presented in Figure 1.

Goodness of fit

The χ2 statistic was significant (415.70, df = 100, p = 0.000), which suggested a degree of model misspecification. It is well recognized however that this statistic is sensitive to sample size (Arbuckle & Wothke, 1999). Thus, other structural diagnostics capable of determining overall model fit while not being sensitive to sample size were additionally considered (Bentler & Bonnett, 1980). The root mean squared error of approximation (RMSEA) of 0.07 was within the acceptable range. Additional goodness-of-fit statistics including the incremental fit index (IFI) (Bollen, 1989) of 0.90 and the comparative fit index (CFI) (Bentler, 1990) of 0.90 all met the 0.90 common threshold, implying an acceptable fit. When taken together, the above mentioned structural diagnostics indicated a very good relative fit of the proposed theoretical model to the underlying data.

Hypotheses testing

As Figure 1 demonstrates, significant support was found for the hypothesized relationships. H1 on the influence of the task environment on resource commitment was strongly supported. Support was also found for the hypotheses predicting both economic and environmental performance (H2 and H3). Finally, H4, which predicted that the environmental performance of reverse logistics is positively associated with the economic performance of reverse logistics was also strongly supported.

5 CONCLUSIONS

5.1 Discussion

As the empirical results demonstrated, the task environment is positively associated with resource commitment. This result indicates that the deployment of a firm’s RL resources depends on external environmental change. To respond to these rapid changes in the task environment, firms must be able to reallocate their limited resource when and where needed to critical positions.

It was also found that resource commitment in RL is positively associated with environmental performance. Businesses can achieve compliance with environmental regulations, a reduction of environmental impact beyond compliance, the meeting of customer expectations, and the enhancement of corporate green image. During times of increasingly stringent international environmental regulations and governmental legislation, such findings are of particular relevance, as environmental innovation and investment (including RL) have become imperative for firms. The rise of consumer environmentalism has additionally influenced the implementation of RL. The empirical results also indicated that resource commitment was positively associated with economic performance. As businesses invest considerable resources into RL activities, they can reduce inventory investments, increase recovery of assets, enhance cost containment, improve business profitability, enhance labor productivity, and improve customer service.

This study further demonstrated that environmental performance is positively associated with economic performance in RL. For most businesses and managers, it is not easy being green, as green efforts are often seen in a cost only light. Being green or adopting environmental management inevitably increases operating costs. In the past, most firms focused on end-of-pipe technologies as the major approach towards pollution control and environmental performance improvements, and environmental investments were often seen as superfluous costs. In recent times however, more and more firms are spending considerable sums adapting to green technologies and adopting proactive environmentally friendly practices.

Yu, Ting, and Wu (2009) discussed the benefits of being green, focusing on the “spillover” or intangible benefits. The potential improvements to a firm's image and reputation resulting from the adoption of green innovations may allow firms to attract more talented workforces and strengthen the loyalty of the increasingly green-conscious customer, potentially increasing the value of a firm’s products (Yu, et al., 2009). Active promotion of environmental innovation initiatives may thus be as critical as the efforts themselves (Yu, et al., 2009). In the short term, environmental performance may be a source of profitability; in the long term, it can become a competitive advantage.

5.2 Limitations

First, this study exclusively considered whether or not firms commit their resources to RL activities. Thus, resource commitment issues were not explored fully and not all possible factors have been taken into calculation on impact on environmental and economic performance. Second, this study focused specifically on manufacturers and retailers in the Taiwanese 3C industry, thus potentially limiting the generalizability of the conclusions. Further studies may wish to focus on other industries or countries, allowing for future comparability.

REFERENCES

Álvarez-Gil, M. J., Berrone, P., Husillos, F. J., & Lado, N. (2007). Reverse logistics, stakeholders' influence, organizational slack, and managers' posture. *Journal of Business Research, 60*(5), 463-473.

Arbuckle, J., & Wothke, W. (1999). *AMOS 4.0 User's Guide*. Chicago: Small waters Corporation.

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

Azzone, G., & Noci, G. (1996). Measuring the environmental performance of new products: an integrated approach. *International Journal of Production Research, 34*(11), 3055-3078.

Bentler, P. M. (1990). Fit indices, LaGrange multipliers, constraint changes, and incomplete data in structural models. *Multivariate Behavioral Research, 25*(2), 163-172.

Bentler, P. M., & Bonnett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*(3), 588-606.

Biederman, D. (2006). Planning for happy returns. *Traffic World, 4*(September), 18-21.

Blumberg, D. (1999). Strategic examination of reverse logistics and repair service requirements, needs, market size, and opportunities. *Journal of Business Logistics, 22*(2), 141-159.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York, NY: Wiley.

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.

Castrogiovanni, G. J. (1991). Environmental munificence: a theoretical assessment. *Academy of Management Review, 16*(3), 542-565.

Chen, Y. S. (2008). The driver of green innovation and green image – green core competence. *Journal of Business Ethics, 81*(3), 531-543.

Chen, Y. S., Lai, S. B., & Wen, C. T. (2006). The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics, 67*(4), 331–339.

Chinander, K. R. (2001). Aligning accountability and awareness for environmental performance in operations. *Production and Operations Management, 10*(3), 276.

Daugherty, P. J., Autry, C. W., & Ellinger, A. E. (2001). Reverse logistics: the relationship between resource commitment and program performance. *Journal of Business Logistics, 22*(1), 107-123.

Daugherty, P. J., Myers, M. B., & Richey, R. G. (2002). Information support for reverse logistics: the influence of relationship commitment. *Journal of Business Logistics, 23*(1), 85–106.

Daugherty, P. J., Richey, R. G., Genchev, S. E., & Chen, H. (2005). Reverse logistics: superior performance through focused resource commitments to information technology. *Transportation Research Part E, 41*(20), 77-92.

Dekker, R., Fleischmann, M., Inderfurth, K., & Van Wassenhove, L. N. (2004). *Reverse Logistics: Quantitative Models for Closed-Loop Supply Chains*. Berlin: Springer.

Dowlatshahi, S. (2005). A strategic framework for the design and implementation of remanufacturing operations in reverse logistics. *International Journal of Production Research, 43*(16), 3455-3480.
Fornell, C., & Larcker, V. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39-50.
Galdeano-Gómez, E. (2008). Does an endogenous relationship exist between environmental and economic performance? A resource-based view on the horticultural sector. *Environmental and Resource Economics, 40*(1), 73-89.
Greer, J., & Bruno, K. (1996). *Green wash: the reality behind corporate environmentalism*. New York: Apex Press.
Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (2006). *Multivariate data analysis* (6 ed.). Englewood Cliffs, NJ: Prentice Hall.
Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of Management Review, 20*(4), 986–1014.
Ilinitch, A. Y., Soderstrom, N. S., & Thomas, T. E. (1998). Measuring corporate environmental performance. *Journal of Accounting and Public Policy, 17*(4), 383.
Jämsä, P. (2009). Opportunities for research in reverse logistics networks: a literature review. *International Journal of Management and Enterprise Development, 6*(4), 433-454.
Jasch, C. (2000). Environmental performance evaluation and indicators. *Journal of Cleaner Production, 8*(1), 79-88.
Jayaraman, V., & Luo, Y. (2007). Creating competitive advantages through new value creation: a reverse logistics perspective. *Academy of Management Perspectives, 21*(2), 56-73.
Judge, W. Q., & Douglas, T. D. (1998). Performance implications of incorporating natural environmental issues into strategic planning process: an empirical assessment. *Journal of Management Studies, 35*(2), 241-262.
Li, X., & Olorunniwo, F. (2008). An exploration of reverse logistics practices in three companies. *Supply Chain Management: An International Journal, 13*(5), 381-386.
Marien, E. J. (1998). Reverse logistics as competitive strategy. *Supply Chain Management Review, 2*(1), 43-52.
Melbin, J. E. (1995). The never-ending cycle. *Distribution, 94*(11), 36-39.
Ministry of Economic Affairs Taiwan. (2008). Retrieved February 17, 2010, from http://w2kdmz1.moea.gov.tw/english/index.asp
Nunnally, J. C. (1978). *Psychometric Theory* (2 ed.). New York, NY: McGraw-Hill.
Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory* (3 ed.). New York, NY: McGraw-Hill.
Richey, R. G., Genchey, S. E., & Daugherty, P. J. (2005). The role of resource commitment and innovation in reverse logistics performance. *International Journal of Physical Distribution and Logistics Management, 35*(4), 233-257.
Rogers, D. S., & Tibben-Lembke, R. S. (2001). An examination of reverse logistics practices. *Journal of Business Logistics, 22*(2), 129-148.
Russo, M. V., & Fouts, P. A. (1997). A resource-based perspective on corporate environmental performance and profitability. *Academy of Management Journal, 40*(3), 534–559.
Scott, S. G., & Lane, V. R. (2000). A stakeholder approach to organizational identity. *Academy of Management Review, 25*(1), 43-62.
Scott, W. R. (1992). *Organizations*. Englewood Cliffs: Prentice-Hall.
Shrivastava, P. (1995). Environmental technologies and competitive advantage. *Strategic Management Journal, 16*(Special issue), 183–200.
Shuangyu, X., & Kohji, H. (2007). Corporate environmental performance evaluation: a measurement model and a new concept. *Business Strategy and the Environment, 16*(2), 148-168.
Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319-1350.

Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review*(May/June), 46-52.
Wu, Y. C., & Chen, W. P. (2006). Reverse logistics in the publishing industry: China, Hong Kong and Taiwan. *International Journal of Physical Distribution and Logistics Management, 36*(7), 507-523.
Yu, V., Ting, H. I., & Wu, Y. C. (2009). Assessing the greenness effort for European firms: a resource efficiency perspective. *Management Decision, 47*(7), 1065-1079.

SUSTAINABLE DEVELOPMENT IN THE CHINESE ALUMINIUM INDUSTRY

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ABSTRACT
This research was carried out to investigate the historical development in the Chinese aluminium industry, with regard to sustainable development of the Closed-Loop Supply Chain (CLSC). In doing so, it identified the development pattern since the 1970s in order to configure next generation supply chains and future development direction. Data and information were collected by case studies and in-depth interviews with local officials, managers and operators in the aluminium industry in Dali town, Pearl River Delta (PRD) region in South China. Analysis and frameworks were developed from the collected information in order to demonstrate the industrial development to provide better understanding of the CLSC for sustainable development, especially with the aim to provide academic and practical understanding and guidelines for emerging industries in their future sustainable development. With the development of Virtuous Spiral Cycle that goes beyond a CLSC, this research provides better understanding of factors that influence the sustainable development of CLSC, and suggests further development of CLSC for higher level of economic, social, environmental and operations management.

INTRODUCTION

Traditional operations management investigates the supply chain operations from the supply of raw materials to the manufacturing and transformation processes of finished products, which are transported to the retailers and finally reaching the consumers. Closed-Loop Supply Chain (CLSC) also consists of the reverse flow of any parts or End-of-Life (EOL) products that are returned from any point of consumption back to their origin. With increasing attention in academic research and industrial activities, it is essential for comprehensive investigation in the CLSC, in order to develop further understanding and guidelines for future sustainable development. In doing so, this research was performed in the context of the Chinese aluminium industry, with the aim to understanding the historical development pattern which contributes in the configuring of future sustainable development in next generation supply chain operations.

LITERATURE BACKGROUND

Sustainability

A number of researchers have defined sustainability in terms of economic dimensions (Pezzy, 1992; Sutton, 1998; Hargroves and Smith, 2005). Economically, sustainability means avoiding major disruptions and collapses, hedging against instabilities and discontinuities (Costanza and Patten, 1995). In addition, Sarkis (2001) identified that the long-term sustainability of corporation depends on the sustainability of the social and natural environment. Sarkis, et al, (2010) further identified that social sustainability can be greatly influenced by various regional and cultural characteristics. Organisations in the supply chain need to take on global perspectives when evaluating environmental concerns. Internally, for manufacturers, the manufacturing function efficiencies and the management of employees and facilities are central to their sustainability goals. This is because sustainable supply chain excellence requires efficient functions of business processes, human system and the enabling technology (Zaklad, et al., 2004). Externally, manufacturers are also expected to make sure the upstream (i.e. suppliers) and downstream (i.e. customers) of their supply chain are meeting social and environmental expectations for recycling EOL products and wastes.

After all, the sustainable supply chain is defined as "management of raw materials and services from suppliers to manufacture or service provider to customer and back with improvement of the social and environmental impacts explicitly considered" (Jorgensen and Knudsen, 2006). Table 1 highlights sustainability across the economic, social and environmental dimensions with three different levels of priorities.

	Economic	Social	Environmental
Sustainability	Level 1: Survival Sustainability		
	Subsistence	Capacity to solve serious problems	Protection of life support systems, Prevention of species extinction
	Level 2: Maintaining Quality of Life		
	Maintenance of decent standard of living	Maintenance of decent social quality (e.g. vibrant community life)	Maintenance of decent environmental quality
	Level 3: Improving Quality of Life		
	Improving standard of living	Improving social quality	Improving environmental quality

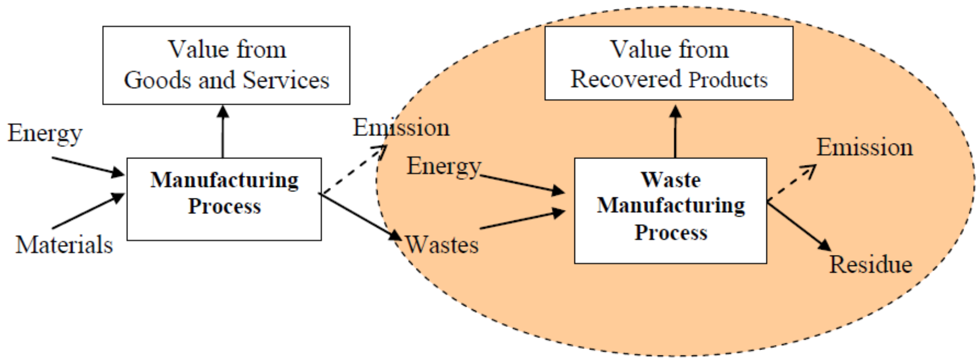
(*Source: Sutton, 1998*)

Table 1. Three Dimensions and Levels of Sustainability

Sutton (1998) pointed out that the survival sustainability must be achieved for ensuring the long-term future stability. However, it is common in many developed and developing countries that effort to improve the standard of living in the short term has been diverting crucial resources and attention away from the long-term maintenance of basic survival capacity. Especially at the survival level, sustainability in any one of the economic, social or environmental dimensions cannot be achieved if sustainability is not achieved in the other two dimensions. Hence, this research is to develop supply chain sustainability with regards to the three dimensions, particularly applying the operations management aspects on minimising non-value added process activities in order to achieve operational efficiency.

Sustainability in Supply Chains

With regard to the three dimensions in sustainability, there are inevitable emissions, wastes and returns during the production of goods and services, which limit the level of sustainability. In addition, there are EOL and used products being returned after customer consumption, which can be collected and recycled for resource utilisation and regeneration of value.



(Adapted: White, et al., 1995)

Figure 1. Material Flows in Manufacturing and Waste Manufacturing Processes

As highlighted in Figure 1, the inputs of energy and materials through the manufacturing processes create value from goods and services produced. Subsequently, wastes from production processes can be collected and become the input materials for the waste manufacturing industry. Economic value can be generated from the remanufacturing processes when recovering secondary products. The purpose of waste manufacturing processes is to help reduce wastes created from the manufacturing industry and provide a material flow back to the point of material consumption, whilst leaving minimum amount of residue for further recollection and disposal.

Attention to Developing Countries

A number of researchers identified that many of the returned products can be profitably sold at a lower price point in the growing 'Secondary Markets' such as outlet malls (Zinszer, 1996; Rogers and Tibben-Lembke, 2001). And reselling products overseas through international transfer is one of the possible ways to dispose returned goods and materials (Gooley, 1998; Blumberg, 2005) The key issues are not just to understand and meet the regulations and requirements of these developing countries, but also to consider the fact that to some extent, the greening of the developed world has been at the expense of the environments in emerging economies (Hart, 1997). There are increasing relocations of the polluting waste recovery activities moving to the developing countries where processes can be done with much lower costs. However, the waste manufacturing processes in the developing markets are largely done manually by low skilled labour with very limited technology and low efficiency. These operations create hazardous problems to the health and safety of the workers and severe pollution and damages to the local environment.

As a result, research is needed to investigate and explore the operations in the context of developing countries. Better guidance is needed for their current and future sustainable development progression. Especially for the emerging economies in countries such as Brazil, Russia, India and China, as these countries are experiencing fast growing manufacturing and economy development in recent decades.

In the study of Zhu, et al., (2008), they look into the insights for different industries in China focusing on a resource based capabilities through knowledge transfer and inter-organisational or inter-industry learning to improve the green supply chain management and CLSC practices adoption. Their research shows that Chinese manufacturers in the power generating industry, chemical/petroleum industries, automobile industry, electrical and electronic industry are still lacking the knowledge, experience and tools to effectively and efficiently improve their environmental performance. Their findings also provided policy implications for the Chinese government in supporting the green supply chain and CLSC practices, in terms of internal environmental management, supplier and customer relationships, investment recovery, and eco-design in different industries.

RESEARCH METHODOLOGY

This paper is part of the PhD research findings from "Contextualisation of Closed-Loop Supply Chains for Sustainable Development in the Chinese Metal Industry" (Huang, 2009). Qualitative empirical research was carried out with semi-structured interviews and observations with local officials (Guangdong Non-Ferrous Metal Technology Innovation Centre) and case companies in the primary and secondary metal manufacturing and remanufacturing sectors in Dali town, PRD region in south China. More than 60 interviews and 168 research hours were performed for data collection. Extensive research analysis and evaluation were carried out based on the data and information from interviews and case observations.

CASE STUDY

Dali town is located in the PRD Region, Guangdong province in south China. It is known as "the Biggest Aluminium Town in China" for its concentration of aluminium production since the 1970s. It has more than 150 aluminium manufacturers and currently producing over 1 million tons of aluminium products annually. These contribute for 60% of the total output values in Guangdong province, and 30% in China as a whole.

Aluminium Supply Chain Development in Dali
It was very remarkable when collecting the historical data and information from the Guangdong Non-ferrous Metal Technology Innovation Centre and some of the interviewees from the case study companies. As a result, data and information could be analysed for illustration according to historical development which contextualise the aluminium supply chain in Dali.

Collecting, Dismantling and Recycling Aluminium in the 1970s
It was until the 1970s when there were scattered small workshops for aluminium productions starting up in the PRD region. At that time, due to the low level of productivity and techniques, the capability for Chinese firms to manufacture aluminium products were extremely limited. The main operations of aluminium were the collection of waste, used and scrap aluminium materials, dismantling of old machineries and mixed daily productions mainly imported from overseas to China. There were mostly manual dismantling processes, in which the mixed aluminium materials and old machines were separated by hand into small parts, sorted according to their characteristics. Then they were cleaned manually before re-melting into aluminium liquids or resizing into different forms, for recycling and reuse. The processes were inefficient, time consuming and only a limited amount of low quality secondary aluminium were recovered. There were quality issues with the remanufactured secondary aluminium in terms of quality standard, the level of impurities and hardness. In addition, there were hazardous actions in these old methods of recycling operations, as there were waste residue which polluted the land, water and air. After all, these were negative effects to the society and the environment, when China was an underdeveloped country in the 1970s.

Development of Aluminium Production in the 1980s
Since the booming economic development in China from the 1980s, more dismantlers found that as they were getting more familiar with their dismantling processes. They were able to modify and improve their dismantling operations. In addition, as some of them have been dismantling old machineries imported from overseas, they accumulated more knowledge in mechanical engineering and machinery designs. Some of the dismantling plant operators started to analyse their work and find out the logic behind their operations. As they were getting very limited value added profits from recycling aluminium, they realised that it would be more profitable to produce primary aluminium products and machinery parts. Therefore, some of them began to investigate in ways to develop better machineries and processes for producing primary aluminium and aluminium products.

As a result, there were production and development of machineries for manufacturing aluminium products. An increasing number of producers moved from the dismantling industry to the production of aluminium, especially in manufacturing aluminium products for the construction industry and some other light industries. In addition to the secondary aluminium collectors in the 1970s, there were aluminium suppliers in the 1980s which provided input resources for manufacturers for their production.

Industrial Expansion in the 1990s
Since the 1990s, as there were further developments in technology, manufacturing equipment, techniques, human labour and resources, it has been a golden era for the aluminium production in the PRD region. The quality level and the complexity of aluminium products have been increasing rapidly, and the production quantity has been growing fast every year. More public and private investments have been attracted to the industry, and the market has been heated up with corporation and competitions among companies in the region. As a result, Dali has become one of the essential centres for aluminium manufacture in China because of its geographic location, labour resource availability, and technology implementation. It produces large quantities of various aluminium products and alloy materials for the Chinese and overseas markets.

In the mean time, the development for aluminium recycling and remanufacturing have been tremendous. Along with the technology development in aluminium production in the region, the process of collecting waste, used and production left-over in the region, sorting and remanufacturing, and applying secondary aluminium into production contributed in developing a relatively high level CLSC flow.

On the other hand, while the primary and secondary aluminium have been developing rapidly in Dali, some issues have been raised. Most importantly, especially at the beginning of the 1990s, when all those manufacturers were investing in aluminium production, not much environmental concerns were taken into account. As the production of aluminium went through physical or chemical processes, aluminium waste residues occurred during manufacturing stages, which were harmful to the land, water and air. Some of the companies did not apply appropriate environmental protection activities when dealing with those hazardous residues, and some of them even dumped the residues in landfill or polluted the water system in the region. These caused dangerous health issues and damages to local residents and the environment. There were also pollution from companies dealing with the collecting, sorting and recycling of waste, used and scrap aluminium, as they were not aware of properly disposing the waste, production residues and cleaning materials. Consequently, it has become the responsibilities of the government, aluminium producers, and those operators in the remanufacturing aluminium processes to tackle the problems caused by their operations.

One of the case companies (AL) has been a leading manufacturing company which also takes into consideration the production residues during its aluminium production. It has developed its own research and development team, and has been working along with a leading university in China, to develop ways to recycle the hazardous waste residue. The operation would turn hazardous aluminium residue into non-hazardous reusable materials Al_2O_3 which can be used for other manufacturing operations, for example, ceramics production. During the regeneration of aluminium residue, it also produces a number of side chemical products which AL sells to other companies in the region as production material resources for their production. More importantly, the operation also helps the company to solve the problem of handling the hazardous production residues, and greatly reduced its production damage to the environment. It should be obvious that by developing this new method of recycling and remanufacturing waste residue for aluminium production, AL generates economic benefits from producing and utilising value-added materials for other operations, contributing in the sustainable development for the aluminium industry.

THE SPIRAL CYCLE OF CLOSED-LOOP SUPPLY CHAIN

With all these developments in the operations of aluminium production in Dali, a framework can be developed as in Figure 2. As in the case of aluminium production and remanufacturing in Dali, the supply chain started from the reverse side ([A]→[B]) in the 1970s. From the 1980s, as technology, production techniques and resource developed, a CLSC was completed in the region ([A]→[B]→[C]). And since the 1990s, there has been a higher efficient flow in the aluminium manufacturing, recycling and remanufacturing ([D]→[E]→[F]). The circle of supply chain continues to grow, and in a spiral circle pattern, as higher levels of technology have been developed for the operation. The CLSC has been expanding and becoming more comprehensive. There are better collaborations between players in the closed-loop cycle. Hence, case studies in this research suggest that the CLSC goes further beyond a closed-loop as a "Spiral Cycle of Closed-Loop Supply Chain" in Figure 2.

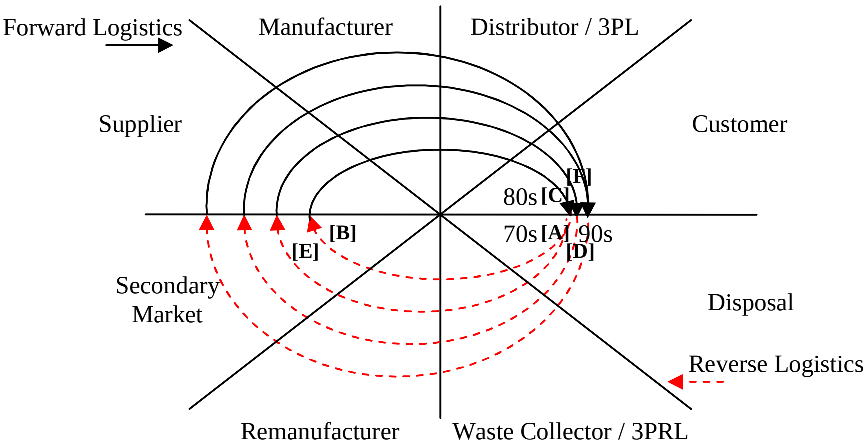


Figure 2. The Spiral Cycle of Closed-Loop Supply Chain

When looking at the spiral from a 3-Dimension perspective, as far as the level of sustainability, the development of production efficiency, level of technology, human resource, knowledge and techniques are considered, the CLSC will be continuously growing upward, which eventually becomes a virtuous cycle, as illustrated in Figure 3.

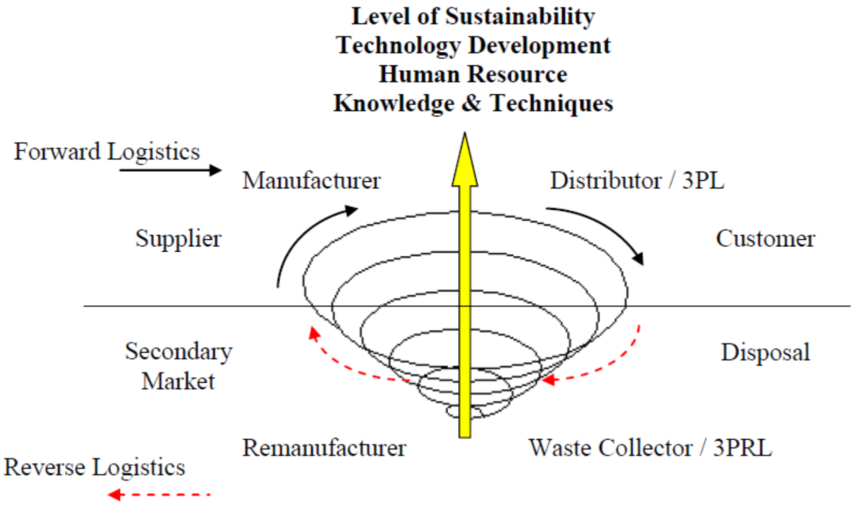


Figure 3. The Virtuous Spiral Cycle of Closed-Loop Supply Chain

It should be pointed out that the supply chain must be completed in a closed-loop in order to go upwards in the virtuous spiral cycle. The closed-loop system can either be external cooperation between companies in the forward and reverse supply chain, or internally with all in-house operations between the forward and reverse supply chain departments within a company. Having either forward or reverse supply chain, would not move up to the higher level but eventually drag down the whole supply chain operation. That is to say, manufacturing without recycling and remanufacturing of wastes, or simply recycling used or waste materials without developing better methods for manufacturing, have negative impacts which would force a virtuous cycle to be a vicious cycle. However, the negative factors that affect the spiral cycles are beyond the scope of this research and would not be discussed further at this point.

The CLSC can also be illustrated as a sequence of circles at different levels of the operation stages being pushed up by various factors. The level of CLSC operations (L) is determined by the Force of Factors (F) between two particular time periods (T), as shown in Figure 4 following. Further research can be carried out to determine the combination of factors that influences the supply chain operation, in order to manage the sustainability of the CLSC.

Consequently, it can be developed progressively as a virtuous spiral cycle towards a higher level in the longer term. However, at this exploration stage of the CLSC in the Chinese aluminium industry, this research only analysed issues and factors that were identified by interviewees from their experiences from the internal and external operations.

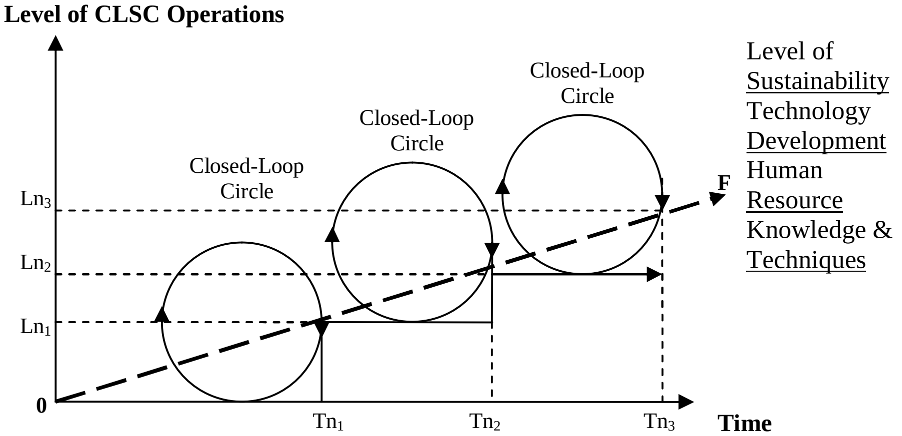


Figure 4 Closed-Loop Supply Chain Development Cycle

Table 2 shows the levels of sustainability of Operations Management in addition to the Economics, Social and Environmental perspectives. From the case findings in the Chinese aluminium industry, levels of operations management also developed overtime in achieving higher level of sustainability. Hence, in addition to the traditional investigation of developing supply chain efficiency and effectiveness, there are higher levels of sustainable development in terms of comprehensive CLSC operation and virtuous spiral cycle that considers factors such as technology development, human resource, knowledge and techniques availability for future sustainable development.

	Economic	Social	Environmental	Operations Management
	Level 1: Survival Sustainability			
	Subsistence	Capacity to solve serious problems	Protection of life support systems, Prevention of species extinction	Work on existing primary and secondary resources
Sustainability	**Level 2: Maintaining Quality of Life**			
	Maintenance of decent standard of living	Maintenance of decent social quality	Maintenance of decent environmental quality	Maintenance of efficient flow of Closed-Loop Supply Chain
	Level 3: Improving Quality of Life			
	Improving standard of living	Improving social quality	Improving environmental quality	Improving production quality & wastes remanufacturing

(*Adapted: Sutton, 1998*)

Table 2. Four Dimensions and Levels of Sustainability

CONCLUSION

With the development of sustainability from the survival level to maintaining quality of life and further improvement, there are higher levels of benefits in economic, social and environmental dimensions. In addition, operations management can develop further with the CLSC managing both forward and reverse logistics flows for sustainable development. In the case of Chinese aluminium industry, this research shows that the CLSC goes further as in the virtuous spiral cycle pattern because of the development in the level of sustainability, technology development, human resource, knowledge and techniques. That is to say, academic and industrial development should not be satisfied with achieving CLSC, the aims and objectives for further sustainable development should always be in the agenda. After all, more academic and empirical research should be performed in order to identify factors that push up the CLSC for sustainable development, in order to guide industrial activities for better efficiency and continuous improvement for the future. There are forces and factors in various industry contexts, which affect the development in the CLSC and virtuous spiral cycle; hence, more research investigation in different contexts will be needed for further analysis.

REFERENCES

Blumberg, D. F. (2005), Introduction to Management of Reverse Logistics and Closed Loop Supply Chain Processes, Florida: CRC Press.
Costanza, R. and Patten, B. C. (1995), "Defining and predicting sustainability", *Ecological Economics*, 15 (3), pp. 193-196.
Gooley, T. B. (1998), "Reverse Logistics Five Steps to Success", *Logistics Management & Distribution Report*, 37 (6), pp. 49-55.
Hargroves, K. J. and Smith, M. H. (2005), (Eds.), The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century, London: Earthscan Publications.
Hart, S. L. (1997), "Beyond Greening: Strategies for a Sustainable World", *Harvard Business Review*, 75 (1), pp. 66-76.
Huang, J. L. (2009), Contextualisation of Closed-Loop Supply Chains for Sustainable Development in the Chinese Metal Industry, *PhD Thesis*, University of Nottingham
Jorgensen, A. L. and Knudsen, J. S. (2006), "Sustainable Competitiveness in Global Value Chains: How Do Small Danish Firms Behave?", *Corporate Governance*, 6(4), pp.449-462.
Pezzy, J. (1992), Sustainable Development Concepts: An Economic Analysis, Washington D. C.: World Bank Environment Paper Number 2.
Rogers, D. S. and Tibben-Lembke, R. (2001), "An Examination of Reverse Logistics Practices", *Journal of Business Logistics*, 22 (2), pp. 129-148.
Sarkis, J. (2001), "Manufacturing's Role in Corporate Environmental Sustainability: Concerns of the New Millennium", *International Journal of Operations & Production Management*, 21 (5/6), pp. 666-686.
Sarkis, J., Helms, M. M., and Hervani, A. A. (2010), "Reverse Logistics and Social Sustainability", *Corporate Social Responsibility and Environmental Management*, Published online in Wiley InterScience, (www.interscience.wiley.com), DOI: 10.1002/csr.220
Sutton, P. (1998), "The Sustainability-Promoting Firm", *Greener Management International*, Autumn 98 (23), pp. 127-152.
White, P. R., Franke, M. and Hindle, P. (1995), Integrated Solid Waste Management: A Life Cycle Inventory, London: Blackie Academic & Professional.
Zaklad, A., McKnight, R., Kosansky, A. and Piermarini, J. (2004), "The Social Side of the Supply Chain", *Industrial Engineer: IE*, 36 (2), pp. 40-44.
Zhu, Q., Sarkis, J. and Lai, K. (2008), "Green Supply Chain Management Implications for 'Closing the Loop'", *Transportation Research Part E: Logistics and Transportation Review*, 44 (1), pp. 1-18
Zinszer, P. (1996), "Supply Chain Strategies for Managing Excess Inventories", *Journal of Marketing Theory and Practices*, 4 (2), pp. 55-60.

THE FUTURE OF SUPPLY CHAINS – THE IMPACT OF AN ENERGY CONSTRAINED, SUSTAINABLE AND LOW-CARBON WORLD

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INTRODUCTION

The future of the logistics service industry is characterised by many challenges and opportunities. Intensifying globalisation and more discerning customer expectations are just two factors which lead to a more turbulent environment. Against this background, future orientation in logistics is required in order to establish flexibility, inspire creativity, and the ability to adapt to changes quickly (Chapman et al., 2003, pp. 630, 640; Flint et al., 2005, pp. 113-114).
Various approaches exists as to how future developments can be analysed: extrapolation of past trends, analysis of historical relationships and analogies, development of future scenarios, or achievement of consensus among experts are just some approaches to 'look into the future' (Piecyk & McKinnon, 2010). Among these methods, scenario planning is considered to be one of the most adequate approaches for long-range planning and its appropriateness to support in decision making under uncertainty has been proven empirically (Schoemaker & Mavaddat, 2002; von der Gracht & Darkow, 2010). Instead of 'predicting' the future, the objective is to create various pictures about possible futures.

The purpose of our paper is to show how the scenario technique can be applied to analyse the future of supply chains in the field of transportation and logistics (T&L) in the year 2030. We developed scenarios which address the question of how supply chains will evolve in the fields of transportation and logistics (T&L) by the year 2030 and aimed at identifying high-impact events and trends which could noticeably affect the industry. Therefore, we compiled the most relevant topics which are considered to shape and influence the future of the T&L industry. As a result of various expert workshops and desk and database research, we identified five sub-segments to analyse in more detail: energy and emission, customer behaviour, transport modes, design of future supply chains, and innovations in the T&L industry were areas of specific interest.

In order to systematically develop valid and robust scenarios, we conducted an innovative global online-based real-time Delphi study. Within the scope of the study, 48 knowledgeable experts in logistics and supply chain management from academia, policy making, and business were asked to share their expectations about future developments in the field of transportation and logistics. Experts were asked to assess 18 future projections in terms of probability of occurrence and impact. Moreover, these experts were asked to provide qualitative arguments to support their quantitative assessment. This information was compiled and analysed, resulting in 18 future scenarios.

LITERATURE REVIEW

Scenarios are appropriate means to focus attention on causal processes and decision making. They represent a hypothetical sequence of logical and plausible events (Kahn & Wiener, 1967) and are defined as internally consistent, narrative, and provocative descriptions about the future (Gausemeier, Fink, & Schlake, 1998; van der Heijden, 2005). Unlike extrapolations or predictions scenarios are purposeful stories about how the future may unfold (Burt, Wright, Bradfield, Cairns, & Van der Heijden, 2006).
Within the scope of scenario planning, two phases can be distinguished: In the first phase, scenario development takes place within a systematic process of picturing and

rehearsing future situations. In the second phase, strategic planning is based on the results of the scenario development process (Bishop, Hines, & Collins, 2007).

Scenarios assist in sharpening planners' perceptions, thinking in alternatives, and dealing with uncertainty by projecting how contextual environments could unfold over time (van der Heijden, Bradfield, Burt, Cairns, & Wright, 2002; Wright & Goodwin, 2009). Despite their various advantages, the application of scenarios in an business context is a relatively new phenomenon (Bradfield, Wright, Cairns, & Van Der Heijden, 2005).
In an extensive literature analysis, Varum and Melo (2010) found that 70 percent of all published scenario articles were published after the year 2000 which underlines the increasing academic interest in the approach. Likewise, a literature review of von der Gracht and Darkow (2010) on scenario planning in the logistics industry confirmed that the frequency on 'scenario publications' accelerated after the year 2000.

Recent research results have proven, that the Delphi method significantly enhances the validity, acceptance, plausibility, and consistency of scenarios by systematically integrating expert knowledge in the scenario development process (Rikkonen, Aakkula, & Kaivo-Oja, 2010; von der Gracht & Darkow, 2010) and consideration of differing views of an expert panel (Rikkonen & Tapio, 2009). It further represents a powerful research technique especially in long-range planning, as expert knowledge is often the only source of information (Linstone & Turoff, 1975). Besides, the Delphi method allows for developing a qualitative and quantitative data base (Rikkonen & Tapio, 2009).

In their bibliography analysis on the theory and application of the Delphi technique, Gupta and Clarke (1996) revealed that between 1975 and 1994 the number of Delphi studies conducted and articles published steadily rose. In addition, Delphi studies became a popular subject for researchers and practitioners. We extended their analysis and reviewed the application of the Delphi method for scenario planning from 2000 onwards. Table 1 gives an overview about the most relevant scenario studies based on the Delphi method and published in academic journals.

Table 1: Literature review on scenario studies based on Delphi method

Autors	**Year**	**Geographical Focus**	**Panel Size***	**Research Detail**	**Time Hori-zon (Years)**
Tolley, Lumsdon, & Bickerstaff	(2001)	EU	72	Identification of future trends in walking in Europe	10
Chang, Wang, Yuan, & Chuang	(2002)	Taiwan	10	Study on the future development of Taiwan's machinery industry	10
Shiftan et al.	(2003)	Israel	32	Development of two future scenarios for the future of the Tel-Aviv metropolitan area	30
Tapio	(2002)	Finland	14	Scenarios on the future of Finnish transport policies	22
Henchion & McIntyre	(2004)	Ireland	14	Forecast developments in Irish food supply chain	6
Rikkonen	(2005)	Finland	N.a.	Alternative scenarios for future agriculture in Finland	20
Michael & Czinkota	(2005)	Global	25	Analysis of likelihood of changes in the international business environment	10
Kaynak & Marandu	(2006)	Botswana	68	Most probable scenario for the tourism industry in Botswana by the year 2020	14
Mason & Alamdari	(2007)	EU	26	Forecast of the structure of air transport in the EU in 2015 in respect of network carriers, low cost airlines and passenger behaviour	8
Rikkonen & Tapio	(2009)	Finland	20	Potential of bio-energy production in agriculture	16
Tseng, Cheng, & Peng	(2009)	No focus	10	Scenarios about the future of the OLED TV market	10
Hameri & Hintsa	(2009)	Global	12	Identification of drivers of change and the implications they will have on international SCM	20

Michael, Czinkota, & Ronkainen	(2009)	Global	34	Possible changes in the international business environment and practice in the next years	10
Celiktas & Kocar	(2010)	Turkey	325	Turkey's renewable energy future	20
Piecyk & McKinnon	(2010)	UK	66	Identification of trends in logistics and SCM and their environmental impact	20

The literature review reveals that the Delphi method has been frequently applied to construct scenarios since 2000. Further, it becomes apparent that the Delphi method is mainly applied for long-term planning horizons. Most of the articles describe a time horizon of more than 10 years, which also represents the necessity for a profound and systematic approach to manage long-term planning in uncertain and volatile environments. Moreover, our literature review reveals that most studies have a constricted geographical focus. However, since the T&L industry is characterised by an international competitive environment with global supply chains (Hameri & Hintsa, 2009), scenario-planning should have an international perspective. Therefore, we develop future scenarios with a global scope.

METHODOLOGY

For the purpose of our research objective, we decided to conduct a real-time Delphi survey in which designated experts assessed future projections about possible developments in the field of T&L in the year 2030. Since the Delphi method has declared advantages to structure the group communication process as it eliminates arising deficits from social pressures (Dalkey & Helmer, 1963; Linstone & Turoff, 1975) and helps to achieve the most accurate group results (Parenté et al., 2005) it is an appropriate method to achieve our research goals.

Delphi Method

The Delphi method is a systematic, interactive forecasting method, in which experts exchange information and knowledge anonymously and reach consensus on topics under review. Experts are sent questionnaires with specific questions concerning future developments, provide their estimations, and send back the questionnaire. A moderator collects the questionnaires, analyses the responses and provides an anonymous summary of the group opinions to the participants. The participating experts then reassess their initial answers in light of the replies from other participants in the panel. This process is repeated until the range of answers decreases and an overall consensus among experts is reached or a pre-defined stop criterion has been achieved. By exchanging information and knowledge among experts and providing regular feedback, it is believed that forecasts of the most probable future are more reliable and valid.

However, the classical Delphi method is quite time-consuming and challenging because the facilitator collects and analyses responses, filters common and conflicting viewpoints, and provides regular feedback until consensus is achieved. Therefore, we developed an online-based real-time Delphi tool which allowed experts to participate in the survey at their convenience by simply following their personalised hyperlink. After experts had started the Delphi survey process, they were asked to assess 18 future projections in terms of probability of occurrence (EP) (scale from 0-100%) and impact on the industry (I) (5 point-Likert scale). In addition, experts were encouraged to provide qualitative arguments to support their responses. Immediately after providing their initial assessment, participants received feedback about how other experts assessed the same projection under review. Thus, they quickly knew whether they departed from group opinion or not. In the light of the new information, experts could reassess and adjust their initial response or provide arguments to support their assessment. After experts completed the first session of the survey, they could re-access the Delphi portal at any time within the survey period and compare their answers with the assessments of other experts.

Development of future projections

In order to create integrated and relevant future scenarios, several activities were conducted to identify the most important topics for the transportation and logistics industry in 2030, such as intensive desk research and several brainstorming sessions were conducted.
As with conventional surveys, the design and development of future projections for Delphi studies can influence the study's validity and reliability. Therefore, we followed rigid research guidelines in the development process of future projections (i.e. short, descriptive, and provocative propositions which describe future states). Hence, projections were not ambiguous, did not include conditional statements, unknown scientific or technological terms. The projections were based on clearly agreed upon definitions (Loveridge, 2002).

Expert selection

The success of a Delphi survey strongly depends on the choice of the right experts for the survey (Baker et al. 2006; Tersine & Riggs, 1976; Welty, 1972). In order to identify those experts, two approaches were pursued. Firstly, intensive desk research was conducted to spot individuals with the right set of expertise. Secondly, SMI´s strong industry experience was used to approach relevant experts. In contrast to other conventional Delphi studies, the objective was not to obtain a representative sample, rather to aim for high expertise. Thus, the aspired expert panel included C-level representatives from prestigious global companies, subject matter experts in strategy, as well as experts from business associations and academics from the fields of logistics and supply chain management.
In total, 64 experts were invited to participate in the real-time Delphi survey. From these 64 experts, 48 agreed to participate in the study, which represents an outstanding response rate of 75%. Various research findings have recommended that a minimum number of 30 experts is required to ensure valid and reliable Delphi results (Parentè & Anderson-Parentè, 1987). In addition, participants were from 20 different countries, of all continents, which ensured a global perspective.

RESULTS OF THE SURVEY

Since large amounts of data were collected during the survey process, results are aggregated and presented in table-form. Statements in italic writing represent actual future projections which were assessed by our expert panel. Assessed probability of occurrence is reflected in the columns headed with EP, while estimated impacts are presented in columns headed with I (5=very high). IQR stands for interquartile range and is an accepted measure to identify whether consensus among experts could be achieved (e.g. De Vet, Brug, De Nooijer, Dijkstra, & De Vries, 2005; Hahn & Rayens, 1999; Scheibe, Skutsch, & Schofer, 1975; Spinelli, 1983). While an IQR equal to or smaller than 25 indicates consensus among experts, higher values represent a dissent. Statements highlighted in light grey include descriptions about possible future scenarios which are based on experts' aggregated assessments, arguments, and relevant information received from desk and database research. As previously stated, we addressed four areas of interest in our study: energy and emissions, consumer behaviour, transport modes, and design of supply chains. The findings of our analysis in these areas are presented subsequently.

Energy/ Emissions			
P1: The oil price has risen to $1000 per barrel because oil production peaked years ago.	**EP**	**I**	**IQR**
	27%	4.6	10
The demand for energy has strongly increased by 2030. Nevertheless, oil prices are still far below four-digit numbers because alternative energies have become an adequate substitute for conventional energy sources.			

	EP	I	IQR
P2: The global energy turnaround has now advanced to the point that in some countries alternative energy accounts for up to 80% of the overall energy mix.	52%	3.8	38
Alternative energy's role in the global energy mix has become significant. In some countries, it represents the largest source of energy. However, some countries still strongly depend on conventional oil resources.			
P3: By using standardised measurement and evaluation systems, the carbon footprint of logistics processes in supply chains must be allocated to the causer and factored into the price of the product.	**EP**	**I**	**IQR**
	69%	4.1	20
As a consequence of climate changes and the awareness of logistics' negative environmental impact, external costs have to be internalised. However, by 2030 a compressive realisation could not be realised. Some countries refuse to internalise external costs.			

Consumer behaviour			
P4: Due to the scarcity of energy resources, the mobility of individuals has strongly decreased.	**EP**	**I**	**IQR**
	46%	3.5	30
Since energy prices have risen strongly in the past, mobility levels of individuals have decreased somewhat. However, individuals consider mobility as a mean to express individuality and aim to maintain a certain level despite high energy prices.			
P5: Work environments, everyday activities, and leisure options are better integrated which has led to considerable reductions in transport	**EP**	**I**	**IQR**
	58%	2.7	28
The way people will work, live, and conduct everyday activities in the future has change and environments are better integrated. New forms of communication technologies have made it easier to work from different places. However, individuals still express their individualism through a certain level of mobility			
P6: Consumer behaviour has changed such that locally produced products are strongly preferred.	**EP**	**I**	**IQR**
	60%	3.9	20
Locally-produced products have become very important by 2030. If possible, local products are preferred. However, since not all products can be produced on a local scale, there is still significant demand for "global" products.			
P7: Personal influence on the logistics process has become more important for customers than the speed of delivery. Customers actively intervene in controlling the delivery process of goods	**EP**	**I**	**IQR**
	56%	3.8	15
As a logical continuance of the trend for individualised products, customers actively intervene in the logistics process. However, logistics service providers aim to limit personal influence to maintain high efficiency levels.			

Transport modes			
P8: Larger means of transport (e.g. gigaliner trucks) have become prevalent in order to compensate for rising transportation costs.	**EP**	**I**	**IQR**
	60%	3.7	25
The usage of larger means of transport has strongly increased. Thus, economies of scales have been realised and transport costs reduced. Nevertheless, infrastructural limitations allow only for the sporadic adoption of larger transport modes.			
P9: The debate over modal shift is obsolete. The share of road transportation in the modal split has further increased.	**EP**	**I**	**IQR**
	50%	3.7	20
Logistics service providers are well aware of the negative impact of road transportation. Therefore, they have switched to more environmentally friendly transport means. However, road transport still offers a higher degree of flexibility and remains important.			
P10: Autonomous and self-controlled systems (agent systems, automatic guided vehicles) have revolutionised freight transport.	**EP**	**I**	**IQR**
	58%	3.9	23
The application of autonomous and driverless vehicles has advanced in the T&L industry in order to deal with increasing personnel costs. Nevertheless, regulatory issues (e.g. liability questions in case of driverless transport) limit the application field of autonomous transport vehicles.			
P11: In order to cope with infrastructural bottlenecks, service providers	**EP**	**I**	**IQR**

control monopolies for deliveries and waste of disposal of entire districts within large megacities.	50%	3.3	23
Infrastructural bottlenecks in megacities have motivated governments to create monopolies to ensure continuous supplies in megacities. However, many problems connected to monopolies (e.g. corruption, inefficiency) still hinder the realisation of centrally organised supplies.			

Design of future supply chains			
P12: The reduction of transportation costs has become the predominant criterion in determining where to set up production sites.	**EP**	**I**	**IQR**
	59%	3.8	20
Since transport costs have strongly increased due to higher energy prices, the location of manufacturing sites strongly depends on the optimisation of transport costs. However, other critical factors (e.g. labour costs, available knowledge) impede production site locations which would minimise transport costs.			
P13: The minimisation of energy consumption is the paramount criterion in supply chain design, rather than cost efficiency and speed.	**EP**	**I**	**IQR**
	55%	3.7	28
Logistics service providers have decreased the speed of delivery in order to reduce energy consumption which directly reduces costs. Since customers still require fast deliveries, it is not possible to reduce the speed of delivery in all cases.			
P14: Global trade and transport only exist for valuable, time-critical or specialised goods. Local procurement, manufacturing, and distribution dominate the commodity markets.	**EP**	**I**	**IQR**
	45%	3.9	30
Globalisation has become irreversible and global trade takes place for even the simplest commodities, which could even be produced locally. However, it can also be observed that the ‘regional markets’ gain in importance and aim to substitute global trade.			
P15: Continuous real-time control of the flow of goods eliminates disturbances in the supply chain and thereby significantly increases resource efficiency.	**EP**	**I**	**IQR**
	71%	4.0	20
Due to major innovations and advancements in IT, disturbances in supply chains could significantly be reduced and resource efficiencies increased. The communication between supply chain partners has become more transparent so that plan variances are detected immediately. Nevertheless, required IT investments are very high so that not all players in the supply chain were able to upgrade their systems quickly enough.			
P16: The logistics world has developed solutions to design flexible and robust supply chains that are resistant to external shocks (economic crises, pandemia, supply shortfalls etc).	**EP**	**I**	**IQR**
	45%	3.8	25
The T&L industry has learned from crises in the past and supply chains have become much more flexible and robust against external shocks. In adition, scientific research has provided numerous solutions to design supply chains more resiliently. Nevertheless, as the diversity of external shocks is steadily increasing, supply chains are not robust against all possible shocks.			

Innovations			
P17: Three-dimensional printing (rapid prototyping, fabbing) has minimised global logistics flows because customers are thereby able to produce simple items and spare parts at home or in decentralised small-scale factories.	**EP**	**I**	**IQR**
	40%	3.5	35
Technological innovations allow customers to fabricate simple products at their homes. However, only a limited amount of customers considers this possibility to be beneficial; most still prefer to order products in “conventional” ways. Mindsets have not changed fast enough that customers are willing to produce products on their own.			
P18: Nanotechnology has significantly improved many means and procedures in logistics (e.g. transport, maintenance, repair and overhaul).	**EP**	**I**	**IQR**
	57%	3.6	25
The application of nanotechnology has accelerated enormously and has found its way into diverse industries. The T&L industry also benefits from nanotechnology. However, although nanotechnology is still very important, its application in the field of T&L is rather limited.			

CONCLUSION

Our research goal was to present different pictures about the transport and logistics industry in the year 2030 and to address the question of how the industry will evolve in an energy-constrained and low-carbon world. By conducting intensive desk research, several workshops, and expert dialogues, we were able to identify five relevant areas of interest to address within the scope of the study. The use of an internet-based real-time Delphi tool allowed for the inclusion of designated experts around the globe, who were willing to share their knowledge and opinions about the future of the T&L industry. Experts evaluated 18 future projections in terms of probability of occurrence and impact on the T&L industry. Based on this information, we were able to create plausible and consistent scenarios to prepare decision makers and organisations for the future

In summary, five central insights can be highlighted:

- The reduction of transport emissions will be a major challenge for logistics service providers. Experts assume and would like that emission fees will be allocated to the causers, who in turn include these costs in calculation of the product price.
- Regional logistics networks will gain in popularity and importance; however, globalisation is an irreversible trend which will not cease until 2030.
- "Sustainable logistics" will offer new business opportunities for the transport and logistics industry.
- The logistics industry will become "greener". Once considered to be an environmental polluter, the industry will develop into a driver of sustainability.
- It will become increasingly important to develop futures competencies within organisations. Thus, organisations will be able to better assess future developments and to prepare themselves for the challenges of tomorrow.

REFERENCES

Bishop, P., Hines, A., & Collins, T. (2007). The current state of scenario development: an overview of techniques. *Foresight, 9*(1), 5-25.

Bradfield, R., Wright, G., Cairns, G., & Van Der Heijden, K. (2005). The origins and evolution of scenario techniques in long range business planning. *Futures, 37*(8), 795-812.

Burt, G., Wright, G., Bradfield, R., Cairns, G., & Van der Heijden, K. (2006). The Role of Scenario Planning in Exploring the Environment in View of the Limitations of PEST and Its Derivatives. *International Studies of Management & Organization, 36*(3), 50-76.

Celiktas, M. S., & Kocar, G. (2010). From potential forecast to foresight of Turkey's renewable energy with Delphi approach. *Energy, 35*(5), 1973-1980.

Chang, P.-C., Wang, C.-P., Yuan, B. J. C., & Chuang, K.-T. (2002). Forecast of development trends in Taiwan's machinery industry. *Technological Forecasting and Social Change, 69*(8), 781-802.

Czinkota, M. R., & Ronkainen, I. A. (2005). A forecast of globalization, international business and trade: report from a Delphy study. *Journal of World Business, 40*(2), pp. 111-123.

Czinkota, M. R., & Ronkainen, I. A. (2009). Trends and Indications in International Business. *Management International Review, 49*(2), 249-265.

De Vet, E., Brug, J., De Nooijer, J., Dijkstra, A., & De Vries, N. K. (2005). Determinants of forward stage transitions: a Delphi study. *Health Education Research, 20*(2), 195-205.

Gausemeier, J., Fink, A., & Schlake, O. (1998). Scenario Management: An Approach to Develop Future Potentials. *Technological Forecasting and Social Change, 59*(2), 111–130.

Gupta, U. G., & Clarke, R. E. (1996). Theory and applications of the Delphi technique: A bibliography (1975-1994). *Technological Forecasting and Social Change, 53*(2), 185-211.

Hameri, A.-P. H., & Hintsa, J. (2009). Assessing the drivers of change for cross-border supply chains. *International Journal of Physical Distribution & Logistics Management, 39*(9), 741-761.

Henchion, M., & McIntyre, B. (2004). Developments in the Irish Food Supply Chain: Impacts and Response by SMEs. *Journal of International Food & Agribusiness Marketing, 16*(2), 103-122.

Kahn, J., & Wiener, A. J. (1967). *The Year 2000: A Framework for Speculation on the Next 33 Years*. New York: MacMillan Press.

Kaynak, E., & Marandu, E. E. (2006). Tourism Market Potential Analysis in Botswana: A Delphi Study. *Journal of Travel Research, 45*(2), 227-237.

Linstone, H. A., & Turoff, M. (1975). *The Delphi Method - Techniques and Applications*. Reading: Addison-Wesley Publishing.

Loveridge, D. (2002). *On Delphi questions* (No. 31). Manchester: The University of Manchester.

Mason, K. J., & Alamdari, F. (2007). EU network carriers, low cost carriers and consumer behaviour: A Delphi study of future trends. *Journal of Air Transport Management, 13*(5), 299-310.

Parentè, F. J., & Anderson-Parentè, J. K. (1987). Delphi inquiry systems. In G. Wright & P. Ayton (Eds.), *Judgemental Forecasting* (pp. 129-156). Chichester: John Wiley & Sons.

Parenté, R. J., Hiöb, T. N., Silver, R. A., Jenkins, C., Poe, M. P., & Mullins, R. J. (2005). The Delphi method, impeachment and terrorism: Accuracies of short-range forecasts for volatile world events. *Technological Forecasting and Social Change, 72*(4), 401-411.

Piecyk, M. I., & McKinnon, A. C. (in Press). Forecasting the carbon footprint of road freight transport in 2020. *International Journal of Production Economics, In Press, Corrected Proof*.

Rikkonen, P. (2005). Scenarios for Future Agriculture in Finland: A Delphi Study among Agri-food Sector Stakeholders. *Agricultural and Food Science, 14*(3), 205-223.

Rikkonen, P., Aakkula, J., & Kaivo-Oja, J. (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.

Rikkonen, P., & Tapio, P. (2009). Future prospects of alternative agro-based bioenergy use in Finland--Constructing scenarios with quantitative and qualitative Delphi data. *Technological Forecasting and Social Change, 76*(7), 978-990.

Schoemaker, P. J. H., & Mavaddat, V. M. (2002). Scenario Planning for Disruptive Technologies. In G. S. Day, P. J. H. Schoemaker & R. E. Gunther (Eds.), *Wharton on Managing Emerging Technologies* (pp. 206-241). New York et al.: John Wiley & Sons.

Shiftan, Y., Kaplan, S., & Hakkert, S. (2003). Scenario building as a tool for planning a sustainable transportation system. *Transportation Research Part D: Transport and Environment, 8*(5), 323-342.

Spinelli, T. (1983). The Delphi decision-making process. *Journal of Psychology, 113*(1), 73.

Tapio, P. (2002). Disaggregative policy Delphi Using cluster analysis as a tool for systematic scenario formation. *Technological Forecasting and Social Change, 70*(1), 83-101.

Tolley, R., Lumsdon, L., & Bickerstaff, K. (2001). The future of walking in Europe: a Delphi project to identify expert opinion on future walking scenarios. *Transport Policy, 8*(4), 307-315.

Tseng, F.-M., Cheng, A.-C., & Peng, Y.-N. (2009). Assessing market penetration combining scenario analysis, Delphi, and the technological substitution model: The case of the OLED TV market. *Technological Forecasting and Social Change, 76*(7), 897-909.

van der Heijden, K. (2005). *The Art of Strategic Conversation* (2nd ed.). Chichester: John Wiley & Sons.

van der Heijden, K., Bradfield, R., Burt, G., Cairns, G., & Wright, G. (2002). *The Sixth Sense. Accelerating Organizational Learning with Scenarios*. Chichester: John Wiley & Sons.

Varum, C. A., & Melo, C. (in press). Directions in scenario planning literature - A review of the past decades. *Futures, In Press, Corrected Proof*.

von der Gracht, H., & Darkow, I. L. (2010). Scenarios for the Logistics Services Industry. *International Journal of Production Economics, In Press, Accepted Manuscript*.
Welty, G. (1972). Problems of selecting experts for delphi exercises. *Academy of Management Journal, 15*(1), 121-124.
Wright, G., & Goodwin, P. (2009). Decision making and planning under low levels of predictability: Enhancing the scenario method. *International Journal of Forecasting, 25*(4), 813-825.

THE IMPACTS OF WEATHER UNCERTAINTIES ON FREIGHT TRANSPORT SUPPLY CHAINS

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ABSTRACT
While much research has been undertaken on the impact of weather uncertainties on the demand side of business', little has been done on the supply side. This paper firstly identifies the impact of weather uncertainties on the freight transport elements of the supply chain, and secondly it assesses the predictability of weather forecasting services to mitigate the impacts of such uncertainties. An existing 'Logistics Triad Uncertainty Model' is utilised for undertaking the analysis. Via a survey of UK logistics practitioners' estimates of weather-related risk are provided based on assessments of delays and monetary losses that weather events cause. The predictability of weather forecasting service depends on the weather event being forecasted. Each weather event is distinctly associated to "possible forecast accuracy" and a "possible level of forecast customization". Particularly with regard to multi-modality, wind is seen to have the most impact on freight transport but it is often the most predictable. The paper concludes that there is major opportunity for utilising weather forecasts to ensure the resilience of multi-modal freight transport chains..

INTRODUCTION
Supply chain uncertainty is the situation when, due to lack of information about the supply chain's environment, decision makers are indecisive on what exactly to do (Vorst and Beulens, 2002). Uncertainties could be initiated from suppliers, control systems, customer or carrier, and have knock-on effects on other parts of the supply chain (Sanchez Rodrigues et al 2007). This paper relates to the uncertainties in the supply chain caused by weather and specifically how they impact freight transport providers. Koetse and Rietveld (2009) mention that transport systems, which play a vital role in supply side of businesses, perform worse in adverse weather conditions. This paper investigates the severity and scale of impacts of weather uncertainties on freight transport aspect of supply chain, by assessing the resulting 'delays' and 'monetary losses'. The first aim is to estimate the risk that different weather events have on various modes of freight transport in the UK. Sanchez Rodrigues et al. (2007)'s 'Logistics Triad Uncertainty Model' provides a logical background for this paper and hence, is chosen to design the conceptual model for the paper.

Businesses extensively use weather forecasting service to predict customer demands based on weather variations, but they rarely use it to mitigate the impacts of weather uncertainties on freight transport (Koetse and Rietveld, 2009). The second aim is to analyse the information available through the 'weather service providers', to evaluate the predictability of weather forecasting services in mitigating the impacts of weather uncertainties on freight transport.

The main research objectives are:
Identify the risk (in terms of severity and frequency) that various weather events have on the different modes of freight transport.
Assess the predictability of a weather forecasting service with regard to freight transport.
The research has specifically focused on the UK and therefore the research is positioned within this context.

IMPACT OF WEATHER EVENTS ON FREIGHT TRANSPORT

Most of the literature related to the impact of uncertain weather conditions on businesses focuses on the short run demand side (Koetse and Rietveld 2009), but there is an impact on the supply side as well. The conceptual model (Figure 1) designed for this study, draws inputs from Sanchez-Rodrigues et al (2007)'s uncertainty model, and explains the impacts of weather related uncertainties on the transport (carrier) aspect of supply chain.

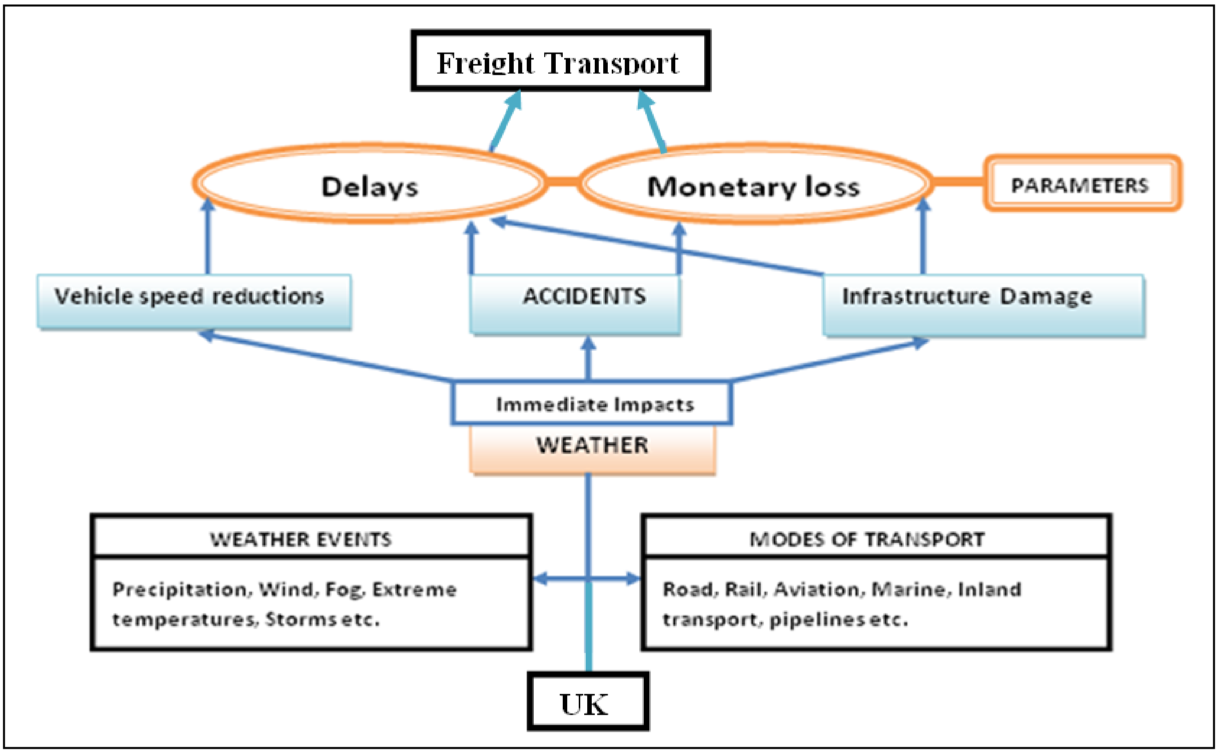

Figure 1: The Conceptual Model

The conceptual model identifies two parameters to gauge the impacts of weather on freight transport: Delays and Monetary Losses. These are the two parameters used to analyse the impact of various weather events on freight transport. Furthermore, the three main ways through which adverse and uncertain weather could cause delays or monetary losses, are: Vehicle Speed Reduction, Accidents and Infrastructure damage. These are termed as 'Immediate impacts' in Figure 1. The two 'parameters' mentioned above are expressed in terms of these three 'immediate impacts' of various weather events on freight transport. Furthermore, the conceptual model is used to assess the scale and severity of impacts of major weather events on different modes of freight transport, in terms of delays, accidents, and infrastructure damage. These different weather events are now discussed in more detail.

Precipitation: Rain and Snow

Although very limited research has been undertaken to determine the mode of freight transport most affected by rain and snow, it is generally recognised that precipitation primarily affects road freight transport in the UK. Edwards (1996) states that specifically in the British Isles, rain is the most common weather hazard for transportation in general. It, being a year round phenomenon, affects the driving conditions on a much higher scale than either fog or snow. Even light rain can cause a 3% reduction in road traffic speed (Pisano et al., 2008). Transport infrastructure damage due to rain is not common but there is a risk of such incidents due to scouring action of rain (Department for Transport. 2005). In the UK, snow could cause extreme damage to road transport (Hargreaves 1976 cited in Edwards 1996). Edwards (1996) considers the impact of snow to be low due to its infrequency and unpredictability. She also mentions that certain areas of Britain, like southern coastal areas of Wales have had snow free winters in past but the snow events increase from southwest towards northeast parts of the country. The severe snowfall in December 2009 and January 2010 brought extensive disruption to logistics networks throughout the UK.

Wind

Perry and Symons (1994) state that Britain is one of the windiest countries in the world. It is not unusual for high winds to result in freight transport carriers facing a range of hazards. Edwards (1996) states that coastal areas of the extreme north and west suffer the windiest conditions, while Midlands and southeast England is least windy. In most counties according to Edwards (1996), around 4% of the total road accidents occur in windy conditions with Kent recording only 0.7% of its annual accidents in windy conditions and east Sussex recording around 6.4%. The effect of winds is the maximum between the months of October and February. Perry and Symons (1994) mention that the records of lane closure of Severn bridge, the principal road link between England and South Wales, indicate that in 1980's the lanes were closed because of high winds for 20 days per annum (on average). They also state that average closure duration is about 7 hours and almost all the lane closures occur in the autumn and winter. These closures could result in failure in customer service, which in long term as well as in short term, could have severe cost implications on freight transport. In terms of road transport, Baker and Reynolds (1994) found that two thirds of all wind related road accidents affected goods vehicles, with high-sided articulated trucks particularly affected. Perry and Symons (1994) mention that aviation is probably the field of transport where wind causes most hazards. In marine transport as well, the hazard caused by high winds, gales and storms is obvious. Perry and Symons (1994) mention that high winds might cause cargo shifts or damage to steering gears.

Fog

Edwards (1996) mentions that in the UK, fog is a less prevalent phenomenon than high winds and rain. Although fog causes only about 3% of annual road accidents, it is still a weather hazard which drivers fear the most (Edwards 1996). According to Maze et al. (2006), fog causes reduced visibility and brings about a reduction in traffic speed up to 12% and this reduction in speed could result in a high cost implication over long periods. Edwards (1996) notes a marked correlation between geographical distribution of fog and related road accidents. She mentions that coastal areas of the UK have least occurrences of thick fog and lower percentage of fog-related road accidents (taken as a percentage of total road accidents), while the central parts of UK have most occurrences of thick fog and higher rates of fog-related road accidents (taken as a percentage of total road accidents).

Extreme Temperatures

Extreme temperatures affect rail transport more than any other mode of transport. In summer of 2003, according to Department for Transport (2005) a number of railway tracks were deformed due to high temperatures. This resulted in reductions in imposed speed limits and hence caused severe delays in freight deliveries. Jorna et al. (2004) also suggest a positive correlation between rail delays and high temperatures. They mention that number of delay minutes (overall) in rail transport in the UK, in 2003 were 165,000 as compared to just 30,000, in cooler summer of 2004. Extremely cold temperatures impact road transport too. For several days in February 2009, the UK had extremely cold temperatures which resulted in formation of ice on major motorways in UK. This prompted route diversions or speed reductions for several freight carriers and resulted in delays freight deliveries (Allen 2009).

METHOD

In order to address the research objectives, the following research approach was adopted. Primary data to evaluate the impact of weather on transport operations was collected through a web-based questionnaire. The questionnaire contained 8 multiple choice questions. These questions were formulated to generate structured responses regarding severity and scale of impacts caused due to weather on freight transport. The questionnaire also had a question that allowed the respondent to describe incidents wherein weather has caused disruption to the freight transport. The survey was sent to 288 transport companies in the UK during the summer of 2009, and 48 responses were received. This gives a response rate of 17%. The respondents used their experiences and knowledge to answer the survey questions. Table 1 shows the distribution of companies that are involved in the survey, based on their modes of freight transport. Although there is a bias in the number of respondants towards road transport, this reflects the fact that road is the dominant transport mode in the UK (Department for Transport, 2008). The data collected from the survey was analysed using pie charts, matrix diagrams etc. The risk of different weather events for the different transport modes was also evaluated quantitatively.

	Road	Rail	Marine	Aviation	Intermodal
No. of companies	23	4	7	3	11
Percentage	48	8	15	6	23

Table 1: Details of companies involved in Survey

The data and information for analysing the predictability of weather forecasting service, was collected through the Met Office website and through discussions with a Met Office employee with a background in weather forecasting and the road transport market. The focus on a single case can be justified as there are only a limited number of weather forecasters within the UK and the Met Office is the largest of these. The discussions focused on the different types of weather event and the degree to which their scale and location can be forecasted. The different types of data available for businesses was also discussed. By combining the results from this stage with the risk assessment from the questionnaire, it was possible to evaluate how businesses could use weather forecasts.

IMPACT OF WEATHER ON DIFFERENT MODES OF TRANSPORT

Firstly, we evaluate the impact of weather on transport operations (objective 1). The respondents to the questionnaire identified the weather events that most frequently and severely affect different modes of freight transport. As in table 2, responses are shown in the form of percentage ratings of frequency and severity of impacts of each weather event on various modes of freight transport. Each column in Table 2 corresponds to a distinct weather event, with the numbers representing the percentage of participants who have chosen that weather event to have the most frequent ('Freq') or most severe ('Sev') impact on various modes of freight transport. For example, number '10', in first row (labelled 'Aviation') and the 'Sev' column within the first column (labelled 'Snow'), implies that 10% of the survey-participants have chosen snow to have the most severe impact on freight transport in UK. Weather events such as flooding and storms, are termed as 'others' in table 2.

% rating	Snow		Fog		Wind		Rain		Extreme Temperature		Other	
	Sev.	Freq.	Sev.	Freq.	Sev.	Freq.	Sev.	Freq.	Sev.	Freq.	Sev.	Freq.
Road	81	18	2	8	9	34	8	40	0	0	0	0
Rail	36	31	25	28	0	0	0	0	32	31	7	10
Marine	0	0	12	12	76	80	0	0	12	0	0	8
Aviation	10	8	55	30	35	57	0	0	0	0	0	5
Intermodal	50	24	6	16	25	50	0	0	19	10	0	0

Table 2: % ratings of frequency and severity of weather related impacts

The risk of each weather event is estimated based on their severity and frequency of its occurrence. The degree of risk is estimated using Sanchez Rodrigues et al. (2007)'s definition of risk, which defines risk related to any event to be a function of severity and frequency of the outcome of that event. Risk is directly proportional to severity and frequency of an event (Henselwood and Phillips, 2008), and to simplify calculations in this study, the degree of risk associated to a weather event is assumed to be a multiplicative product of severity and frequency of impact of that event is normalised to a scale from 0 - 1.

$$\text{Risk associated with a weather event} = \frac{Severity \cdot Frequency}{100} \qquad \ldots(1)$$

The risk values obtained were then categorised into four types: low, moderate, moderate-high and high. The risk (with regard to freight transport) associated to various weather events is expressed in Figure 2, where each circle represents a distinct risk category. The matrix gives a clear picture of the degree of risk that various weather events have on different modes of freight transport in the UK.

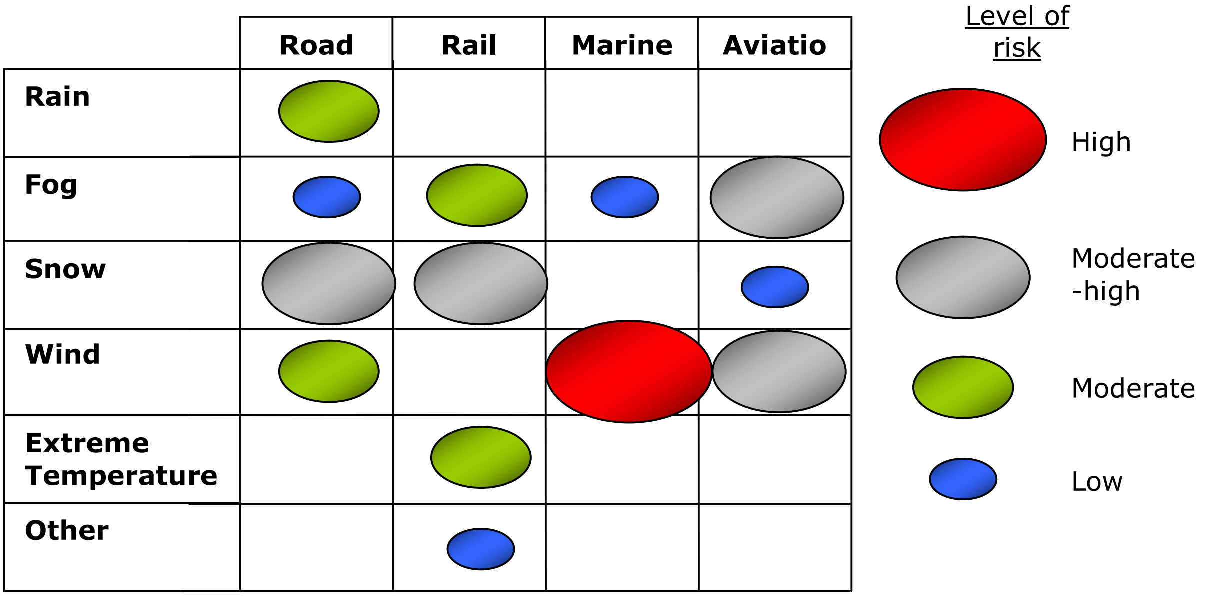

Figure 2: Risk Estimation

As shown in the Figure 2, snow is a moderate-high risk event for almost all the modes of transport in UK. This reflects the earlier findings reported in the literature (Hargreaves 1976 cited in Edwards 1996). Wind is a high-risk event for marine transport, and moderate-high risk event for aviation and inland transport in UK. In addition, fog is a moderate-high risk event for aviation transport. Rain does not have a major impact on any mode of freight transport although it is a year round phenomenon in the UK. Extreme temperatures too are moderate or low risk event for freight transport in UK.

USE OF WEATHER FORECASTING SERVICES

As well as the assessment of severity and impact that different weather events had, respondents were asked about their use of weather forecasting services to counter weather uncertainty. 75% of the survey respondents stated that they do not use any weather forecasting services. These findings indicate that the usefulness of weather forecasting service (to counter the impacts of weather uncertainties on freight transport) is possibly not well known in the UK. This section presents a brief overview on predictability of weather forecasting service and hence, usefulness of a weather forecasting service, with regard to freight transport.

Weather forecast predictability is determined by the ease with which various weather events are predictable. Ease of predictability of forecast related to any weather event is determined by two main factors: firstly, 'Possible Level of Forecast Customization' and secondly, 'Possible Level of Forecast Accuracy'. These factors vary from one weather event to another. The 'Possible level of forecast customization' means the level of detail (with respect to a weather event) that could be predicted for the chosen carrier routes. The 'Forecast Accuracy' refers to the preciseness of forecast related to a weather event. 'Possible Level of Forecast Accuracy' depends primarily on the weather event being forecast, however it also depends on two other factors. Firstly, Forecast Length (forecast lead time), that is, how far ahead in time the forecast is undertaken. Forecasts for longer lengths, are generally less accurate than forecasts for shorter lengths of between 36 to 48 hours. Secondly, Forecast Grid Size (model resolution) the geographical unit of the total forecast area. The larger the 'Forecast Grid Size' (i.e. 'model resolution', is in part directly related to the 'forecast lead time'. 'Model resolution' increases with decreasing 'forecast lead time') the lower the accuracy of the forecast.

Figure 3 shows the possible levels of customization and accuracy of forecasts related to various weather events. Forecasts related to events like winds, which are identified as high risk events for marine freight transport, could be highly customized and forecasted with higher levels of accuracy as compared to other weather events. However, risks related to weather events like snow are more difficult to predict accurately for a long forecast length (Forecast lead time). Risks associated with fog and extreme temperatures can also be predicted fairly accurately for long forecast length, but the level of customization, in both cases is only moderate. The forecasts related to weather events closer to the top-right corner of Figure 3, like wind or extreme temperatures, are more predictable than forecasts related to weather events closer to the bottom-left corner, such as snow.

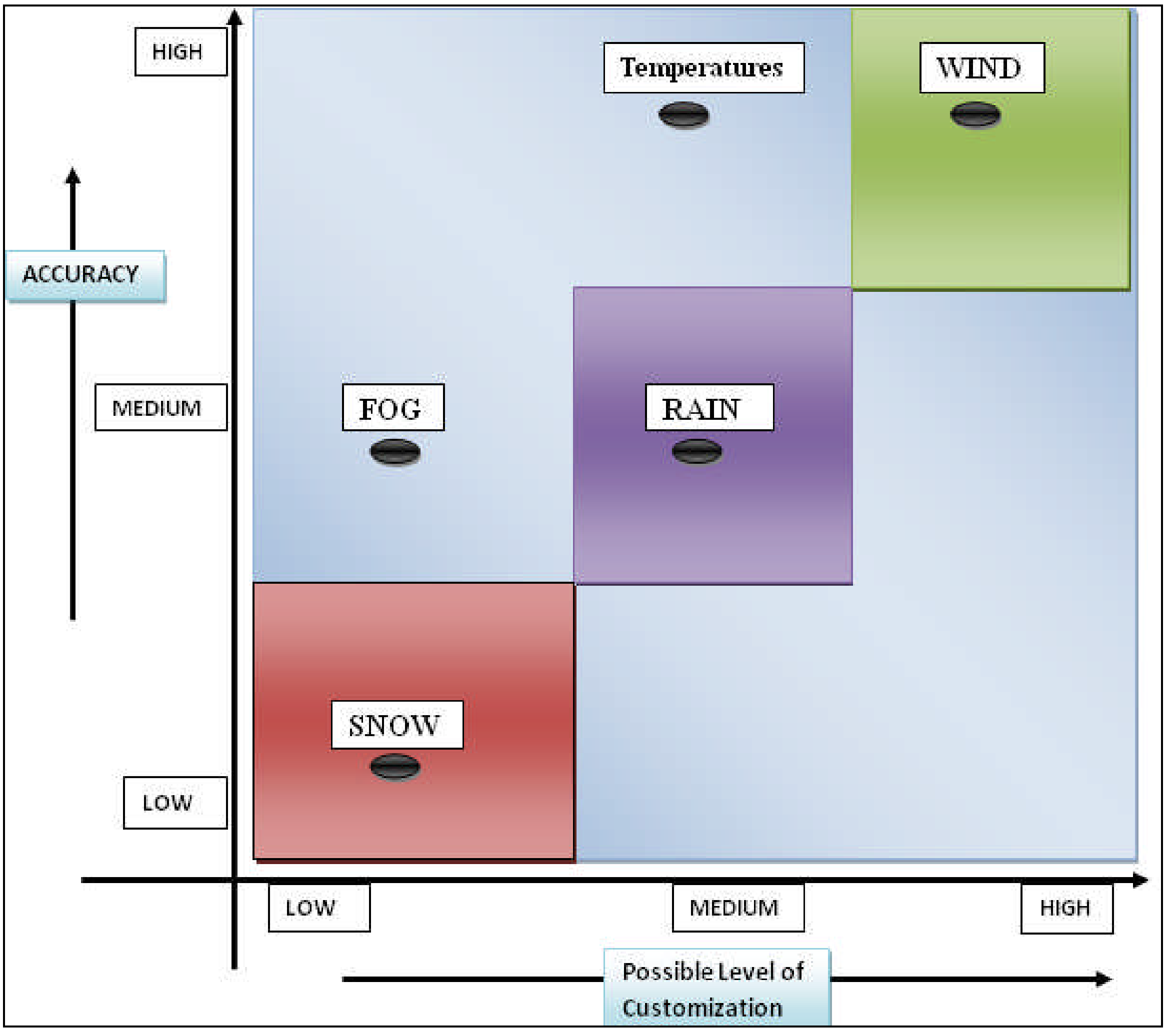

Figure 3: X-Y Scatter Diagram for accuracy vs 'Possible Level of Customization'

DISCUSSION AND CONCLUSION

In relation to research objective 1, the review of the literature and the findings from the primary data analyses indicate that very few weather events are of high risk to freight transport in UK. For example, strong winds are highly risky to marine transport. However, there are a number of moderate-risk events such as:
Fog - for aviation
Snow - for road, rail and inland transport
Wind - for aviation and inland transport

Certain weather events like snow, that are identified as highly risky, especially to road freight transport in UK, are only moderate-high risk events because of their infrequent occurrence in most parts of the UK. Impacts of most of the weather events may be classified as manageable by UK freight transport operators. However, considering the impacts of a number 'weather affected' freight transport activities collectively, clearly show the time that businesses lose due to weather uncertainties. For example, light rain / snow cause only 3% reductions in traffic speed (Pisano et al. 2008). If we consider such reductions in traffic speed for 100 rain affected freight transport activities which are supposed to have an actual journey time of 6 hours, the total time lost would add up to 18 hours, equivalent to three freight transport activity times.

Another impact of weather that is not evident from the findings is the ripple effect it causes. The ripple or the 'knock-on' effect of weather is most visible in inter-modal freight transport, where disruption in operations of any one mode of freight transport, affects the overall 'multimodal freight delivery time' and hence affects the overall supply chain. 20% of the survey respondents represent the companies that use multimodal freight transport for their freight transport operations. Three quarters of these respondents have mentioned at least one weather related incident that, in the recent past, has delayed the multi-modal freight transport delivery by affecting the operations of one of the modes of their multimodal freight transport supply chains. A generic issue that comes out through the survey responses is regarding the disruption of international multimodal freight transport supply chain due to wind-inflicted delays in marine freight transportation. Survey participants have mentioned a number of incidents wherein marine freight transport, which forms one of modes of multimodal freight transport, has been disrupted by strong winds and hence caused delays to the multimodal freight transport supply chain. Survey responses also point out a few incidents wherein strong winds have indirectly affected the multimodal freight transport supply chains by disrupting the intermediate activities like the load-unload operations of cranes at ports. Impacts of such weather induced delays affects the multimodal freight transport supply chain as a whole due to linear interdependence of various mode of multimodal freight transportation.

Turning to research objective 2, the results of this study indicate that there is limited usage of weather forecasting services for mitigating the impact of weather uncertainties on freight transport in the UK. Two main reasons for this are the low frequency of occurrence of severe weather disruptions that have immediate cost implications and most of the businesses in the UK are not fully aware of usefulness of weather forecasting service in freight transport. It may be concluded that the freight transport businesses see weather forecasting services as not of direct value-adding' to their operations. This means that weather related impacts that do not have immediate or evident cost implications on freight transport, have become 'part and parcel' of the freight transport supply chain in the UK.

Usage of weather forecasting in freight transport could reduce delays in the supply chain and hence add to total customer value. However, there are some limitations to the accuracy and level of customization of forecasts related to some weather events like snow and fog.

The estimation of risk associated with each weather event, is based on the responses to the questionnaire-based survey, and could vary with number of survey-respondents. In addition, the accuracy related to a forecast depends on the 'forecast length' and the 'forecast grid side'. These dependencies are not elaborated in this paper.

There is limited literature related to impact of weather on freight transport (specifically). This could be a future research topic. The cost implications of adverse weather, that are specific to freight transport, could be an interesting research area.

REFERENCES

Allen, N. (2009) "Snow Britain: Big chill II brings travel chaos", The Daily Telegraph, 5 February 2009.

Baker, C.J. and Reynolds, S. (1994) "Wind-induced accidents of road vehicles", Accident Analysis and Prevention, 24(6) 559-575.

Department for Transport (2005) "The changing climate: its impact on the Department for Transport", available at: http://www.dft.gov.uk/pgr/scienceresearch/key/thechangingclimateitsimpacto1909?page=4#a1003 [Accessed: 8 July 2009].

Department for Transport (2008) "Delivering A Sustainable Transport System: The Logistics Perspective", London: Crown copyright, available at: http://www.dft.gov.uk/pgr/freight/dastslogistics/dastslogisticsperspective.pdf [Accessed: 7 July 2009].

Edwards, J.B. (1996) "Weather-related road accidents in England and Wales: a spatial analysis", Journal of Transport Geography, 4(1) 201-212.

Hargreaves, M.I. (1976) "Statistics of snow depth at selected stations in England and Wales and Northern Ireland, Nov. 1946-April 1973", Climatological Memorandum 76, HMSO: London.

Henselwood, F. and Phillips, K.G. (2008) "The Development of Risk Criteria for High Severity Low Frequency Events", Process Safety Progress, 28(1) 11-14.

Jorna, R., Velden, A.V., Peelen, M. and Rietkerk, A. (2004) "Implementation of Incident Management on secondary roads in The Netherlands", Association for European Transport, available at: http://www.etcproceedings.org/paper/download/1372 [Accessed: 9 July 2009].

Koetse, M.J. and Rietveld, P. (2009) "The impact of climate change and weather on transport: An overview of empirical findings", Transportation Research Part D, 14, 205-221.

Maze, T.H., Agarwal, M., Burchett, G. (2006) "Whether weather matters to traffic demand, traffic safety, and traffic operations and flow", Transportation Research Record, 1948, 170-176.

Perry, A. and Symons, L. (1994) "The wind hazard in the British Isles and its effects on transportation", Journal of Transport Geography, 2(2) 122-130.

Pisano, P.A., Goodwin, L.C. and Rossetti, M.A. (2008) "U.S. highway crashes in adverse road weather conditions", Proceedings of the 24th Conference on IIPS, available at: http://ams.confex.com/ams/88Annual/techprogram/paper_133554.htm [Accessed 3 July 2009].

Sanchez Rodrigues, V, Stantchev, D., Naim, M, Potter, A. and Whiteing, A. (2007) "Establishing a transport operation focused uncertainty model for the supply chain", International Journal of Physical Distribution and Logistics Management, 38(5) 388-411.

Van der Vorst, J. and Beulens, A. (2002) "Identifying sources of uncertainties to generate supply chain redesign strategies", International Journal of Physical Distribution and Logistics Management, 32(6) 409-430.

Womack, J.P. and Jones, D.T. (1996) "Lean Thinking", New York: Simon & Schuster.

APPLYING LEAN PRINCIPLES TO ACHIEVE CONTINUOUS FLOW IN 3PLs OUTBOUND PROCESSES

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INTRODUCTION

The concept of continuous flow is closely associated with the lean management philosophy. Lean management is defined as "a system of measures and methods which when taken all together have the potential to bring about a lean and therefore particularly competitive state, not only in the manufacturing division, but throughout the entire company" (Warnecke & Hüser, 1995, p. 38). The objective of lean is to streamline the flow of production while continuously seeking ways to add value by accomplishing "more with less." Any obstacles in the system inhibiting flow are referred to as waste (Womack, Jones, & Roos, 1990). Flow, in terms of lean management, is conceptualized as the continuous movement from products and materials from one process to the next throughout the supply chain. It is closely linked to the well-known pull principle, to make sure that only the products required by customers are forwarded. Lean management principles and practices have been traditionally applied to manufacturing systems. In view of this, the primary aim of the present paper is twofold. First, we argue that the lean management concept and principles can also be applied to operations performed by logistic service providers (LSPs). Second, focusing on the outbound processes of a large LSP, we empirically investigate whether the principles identified by Womack and Jones (1996) to make products flow through the supply chain without interruptions indeed help accomplish flow.

LEAN MANAGEMENT OF FLOW IN LOGISTICS OPERATIONS

Supply chains consist of distinct, yet to some extent integrated, production facilities linked by transport and storage services. A recent trend is that companies outsource internal logistic processes more and more to third party logistics providers (3PLs). As a consequence, the supply chain becomes more complex because the direct flow of goods and information between the OEM and end customers is diverted via the 3PLs. Interestingly, the outsourcing trend also brings about a different conception of the added value of logistic processes. While storage in the tradition of Just In Time used to be perceived as a non-value adding and costly activity, covering up production defects (Krafcik, 1988), outsourcing this function to a 3PL enables the OEM to concentrate on its core activities. Thus, as a result of the strategic outsourcing decision, logistic services performed by 3PLs have turned into value adding activities for an OEM. However, at the operational level lean practices may be employed to reduce waste in internal processes, thereby enhancing the added value of logistics even more. An LSP's internal processes can be subdivided in inbound processes (receiving and storing goods) and outbound processes (picking, value added services, and shipping) (Gu, Goetschalckx, & McGinnis, 2007). To limit the scope of our study, we concentrated on the outbound processes. Thus, the primary research question is whether and how lean management principles and practices can help accomplish continuous flow in an LSP's outbound processes, such that goods demanded by customers are handled by these processes without obstacles, and storage can be kept to a minimum. Table 1 shows the characteristics of input, process content and output of each of the outbound activities, showing that the output of one activity becomes input for a subsequent activity.

	Input	Process	Output
Picking	Customer order	Take the products out of storage and into value –added services area or shipping area	Products ready for application of value-added services or shipping
Value-added services	Products in need of value-added services	Apply required value-added services	Products ready for shipping
Shipping	Products ready for shipment	Prepare products for shipment (e.g. labels, sealing) Select appropriate carrier Load products into truck	Truck with loaded customer orders ready for transport

Table 1: Input-process-output model for outbound processes of a public warehouse

Womack and Jones (1996) identified three conditions for making products flow through the supply chain. First, "focus on the actual object" requires demand management that balances the customer's requirements with the capabilities of the process (Croxton, Lambert, Garcia-Dastugue, & Rogers, 2002). At the strategic level demand management means that the LSP should not aim to serve clients whose demands cannot be met. At the operational level, demand management is concerned with forecasting and scheduling of orders and accompanying outbound processes. Second, "rethink work practices" requires that processes become standardized and more predictable. Standardization of operations and the times needed for those operations are probably the most well-known form of standardization. However, even the work in progress can be standardized by consolidating and re-dividing customer orders in the service of predictability. Third, "ignore traditional boundaries" means that employees who are multiskilled contribute to flow because they can easily switch between processes. The necessary skills need to be determined and training and recruitment need to ensure that workers actually possess these skills. These prerequisites for continuous flow equally apply to the outbound processes picking, value-added services, and shipping. Combining the conditions for flow with these processes, we arrive at the theoretical framework shown in Table 2.

EMPIRICAL RESEARCH DESIGN

To further narrow down the scope of the research, the focus in this study is on the operational aspects of achieving a continuous flow. In Table 2, this area is bounded by the bold line. Hence, the effects of operational demand management and all forms of standardization on the accomplishment of flow in the outbound processes are considered, but not the strategic and human resource aspects. The research was conducted with Menlo Worldwide Logistics (MWL) at the Eersel facility in the Netherlands, Menlo's largest site in the Netherlands. Next to receiving, storing, and shipping services, it offers cross-docking opportunities and various value-adding services such as kitting, labeling and configuration. Nine different clients (accounts) are hosted, with different characteristics and customized service requirements. For the present research the account that exhibited the largest variation in terms of the required value-added services was chosen. As of now, this account will be referred to as account X. Three types of data were collected: documentation, interviews, and observations. Documentation includes internal documents provided by MWL, such as training materials and standard operating procedures. Interviews were conducted with employees responsible for supervision, planning, picking, value-added services, and shipping for this particular account. Observations include on site time and inventory measurements over a four-week period.

			Outbound processes		
			Picking	Value-added services	Shipping
Continuous flow prerequisites	Demand management	Strategic demand management	Order drop fit	Value-added services fit	Shipping requirements fit
		Operational demand management	Value-added services triggered scheduling	Shipping triggered scheduling	Order triggered scheduling
	Standardization	Standardized work	Picking processing	Value-added services processing	Shipping processing
		Standardized time	Picking batch time	Value-added services batch time	Shipping batch time
		Standardized work in process	Picking batch size	Value-added services batch size	Shipping batch size
	Multiskilled workers	Skill association	Order triggered skill association	Value-added services and order triggered skill association	Order triggered skill association
		Training and recruitment	Picking capacity requirements triggered training and recruitment	Value-added services capacity requirements triggered training and recruitment	Shipping capacity requirements triggered training and recruitment
		Compensation	Gainsharing	Gainsharing	Gainsharing

TABLE 2: THEORETICAL FRAMEWORK

CONDITIONS FOR CONTINUOUS WORKFLOW AT MENLO

Menlo is able to handle all demands made by account X in terms of requested services and capacity. At the end of each quarter additional capacity is required which is supplied by temporary labour and employees from other accounts. Once an order is ready for shipping, a pre-alert is sent to the client of X. When required, clients can pick up orders at Menlo Worldwide. Most of the time it takes several days for the customer to collect the order. These orders are stored separately, taking up additional warehouse space. Figure 1 shows the average inventory during the day for account X at Menlo.

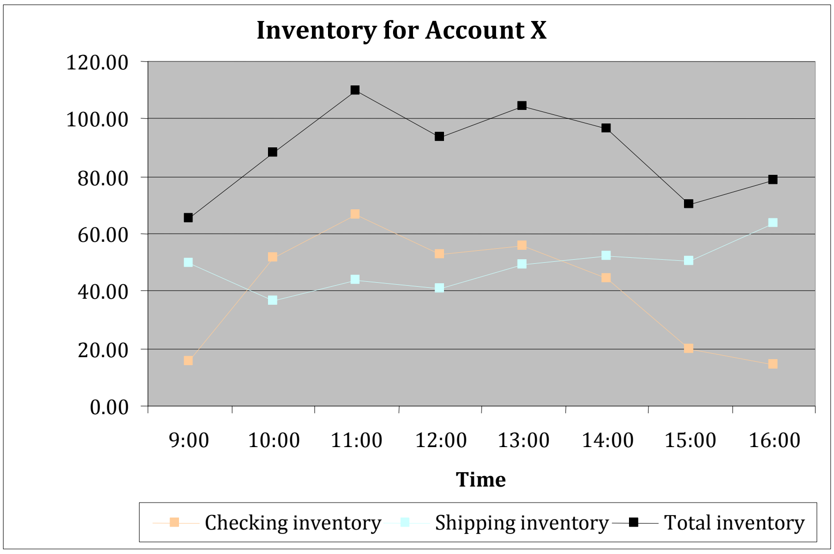

Figure 1: Inventory levels for account X at Menlo

The regular sequence of processes for an order is picking→checking→kitting (optional)→ packing→shipping, but inventory was only measured for the checking and the shipping stages. Menlo applies a forward scheduling system. As the picking process is initiated by the customer order, goods are pushed from one process to the next. All employees are able to perform all the outbound processes and rotate between these processes. The checking is almost always done by the same person.

As Menlo Worldwide has standardized processes, account X is served on the basis of standard operating procedures and standard work instructions for all processes. Observations have shown that these work instructions are followed quite literally. Menlo has a system in place for calculating the cycle time of customer orders based on the number of lines. This system is used to consolidate the customer orders into batches that have a cycle time of thirty minutes. At the moment Menlo is collecting data to develop the same system for the other processes. As this is not yet complete, there is no use of a standard work in process throughout the whole organisation of Menlo. Based on the inventory levels and observations at Menlo, Table 3 shows our general assessment of the conditions for continuous flow at Menlo.

	Picking	**Value-added services**	**Shipping**
Demand management			
Strategic	+	+	+/-
Operational	+/-	+/-	+/-
Standardization			
Work	+	+	+/-
Time	+	+/-	--
Work in progress	--	--	--
Multiskilled workers			
Skill association	--	--	--
Training and recruitment	--	--	--

Table 3: Conditions for continuous flow at Menlo

For account X, picking is the dominant process. The number of people allocated to the processes influences inventory levels between the processes. Adapting the number of people allocated to a process to the actual workload reduces the fluctuation of inventory. This requires flexibility which is provided by multiskilled workers.

CREATING CONTINUOUS FLOW AT OUTBOUND PROCESSES FOR ACCOUNT X

Our observations suggest that for this account Menlo is on its way to achieve a continuous flow. However, the high level of inventory between the various processes indicates remaining problems.

The main problems identified are:

- Uneven division of people per process per hour
- No standard batch time for all processes
- No process scheduling
- Lack of visual management
- Lack of process control.

Table 4 relates these problems to the three conditions for continuous flows.

Problem\ Condition	Demand management	Process standardization	Multiskilled workers
Uneven division of workers	X	X	X
No standard batch time		X	
No scheduling	X	X	
Lack of visual management		X	
Lack of process control	X	X	

Table 4: Process characteristics and conditions for continuous flow

Table 4 shows that all problems can be related to standardization, hence this condition should be addressed first. The data from account X were used to generate solutions for the problems that were identified. Especially the relatively high and fluctuating inventory levels between the processes makes backward scheduling cumbersome. Moreover, high inventory is indicative of lack of flow. Therefore, our point of departure for the proposed changes in the system is the concept of "heijunka" taken from the lean literature: Inventories will be minimized and flow will be maximized if all processes produce exactly the same volume of output per unit of time. Orders are consolidated in batches of thirty minutes of work and are then given to the pickers. For this example we assume 252 orderlines in total, which is representative of the daily activities for account X. Because a working day is 7,5 hours, i.e. 15 blocks of 30 minutes, and all inventory is supposed to be zero at the end of the day, 12 blocks of 252 / 12 = 21 orderlines can be processed per block. The time per orderline for each process is shown in Table 5.

Process	Time per orderline (minutes)	# Orderlines / 30 minutes
Picking	1.37	19
Checking	0.17	107
Kitting	2.12	14
Packing	1.27	21
Shipping	4.54	6

Table 5. Process times account X (old)

Table 5 shows that to follow the flow of picking, there need to be 107/19 = about 5,6 checkers for every picker. The first step of the proposed solution is to combine the picking and checking processes. Table 6 shows that now the system is much more balanced.

Process	Time per orderline (minutes)	# Orderlines / 30 minutes
Picking / checking	1.54	16
Kitting	2.12	14
Packing	1.27	21
Shipping	4.54	6

Table 6. Process times account X (new)

Table 6 also shows that the packing process can be staffed by one Full Time Equivalent (FTE), because packing exactly meets the requirement to process 21 orderlines per 30 minute time block. Next, we calculated the number of FTEs needed for the other processes, to enable the entire system to process 21 orderlines. For picking/checking, 21/16 = 1,3 FTE is needed, for kitting 21/14 = 1,5, for packing 1, and for shipping 21/6 = 3,5. Tables 7 and 8 now show the allocation of staff to processes and the output of the processes producing a continuous flow by taking into account the aforementioned recommendations.

	Picking/checking	Kitting	Packing	Shipping
08:30-09:00	1,3			
09:00-09:30	1,3	1,5		
09:30-10:00	1,3	1,5	1	
10:00-10:30	1,3	1,5	1	3,5
10:45-11:15	1,3	1,5	1	3,5
11:15-11.45	1,3	1,5	1	3,5
11:45-12:15	1,3	1,5	1	3,5
12:15-12.45	1,3	1,5	1	3,5
12:45-13.15	1,3	1,5	1	3,5
13:45-14:15	1,3	1,5	1	3,5
14:15-14:45	1,3	1,5	1	3,5
14:45-15:15	1,3	1,5	1	3,5
15:30-16:00		1,5	1	3,5
16:00-16:30			1	3,5
16:30-17:00				3,5

Table 7. Allocation of workers (in FTEs) to processes

	Picking/checking	Kitting	Packing	Shipping	Total
09:00	21				21
09:30	21	21			42
10:00	21	21	21		63
10:30	21	21	21	21	84
11:15	21	21	21	21	84
11.45	21	21	21	21	84
12:15	21	21	21	21	84
12.45	21	21	21	21	84
13.15	21	21	21	21	84
14:15	21	21	21	21	84
14:45	21	21	21	21	84
15:15	21	21	21	21	84
16:00		21	21	21	63
16:30			21	21	42
17:00				21	21
Orderlines	252	252	252	252	

Table 8. Output (# orderlines) per process per 30 minute block

The proposed solution has two major advantages. First, in comparison to the inventory levels shown in Figure 1, the level of inventory during the day has decreased, has become much more stable, and the system is "clean" at the end of the day and, accordingly, at the beginning of the next day. Second, the flow of orders has now become completely predictable, enabling backward scheduling. For instance, an order picked between 8:30-09:00 is ready for dispatch between 10:00-10:30. Numerous advantages derive from enhanced system predictability in terms of warehouse space occupied, transport and, ultimately, client satisfaction. Obviously, safety margins need to be built in to account for unpredictable disruptions. However, this case shows that the standardization of processes and process times can bring about significant gains in terms of continuous flows, thereby considerably improving the predictability and controllability of the system.

DISCUSSION AND CONCLUSION

In this paper we have argued that the lean principles developed for a manufacturing environment might be equally applicable to the operations of logistic service providers. In particular we have focused on the concept of continuous flow. On the basis of empirical data obtained from the outbound processes at a large Menlo Worldwide Logistics facility in the Netherlands we have shown that under conditions of demand management, standardization, and multi-skilled workers, continuous flow can be achieved. Both standardization and the allocation of workers to processes helped reduce the inventory levels between processes and enhance the predictability and controllability of the processes. A limitation of this study is that the simulated data have not been observed in practice. Also, we cannot be sure that the proposed measures will similarly apply to inbound processes.

REFERENCES

Croxton, K. L., Lambert, D. M., Garcia-Dastugue, S., & Rogers, D. S. (2002). The demand management process. *International Journal of Logistics Management, 13*(2), 51-66.

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on warehouse operation: A comprehensive review. *European Journal of Operational Research, 177*, 1-21.

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan Management Review, 30*(1), 41-52.

Warnecke, H. J., & Hüser, M. (1995). Lean production. *International Journal of Production Economics, 41*, 37-43.

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporation*. New York: Simon & Schuster.

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

THE IMPACT OF LOGISTICS RESOURCES ON PERFORMANCE: A SURVEY OF MALAYSIAN LOGISTICS SERVICE PROVIDERS

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INTRODUCTION

In the competitive world, it is essential for logistics service providers (LSPs) to gain access to, and transform the right resources into superior logistics performance. There is some indications in the current logistics literature, that logistics resource such as technology, relationship, transport vehicles, and people are determinants of LSPs' logistics performance (Chiu 1995; Sink *et al.*, 1996; Gunasekaran and Ngai, 2003; Brah and Lim, 2006). However, there is still a lack of research which conceptualizes and measures the constructs of logistics resources and further tests their impacts on logistics performance. This study identifies, conceptualizes, and measures logistics resources accessed by LSPs, and further examines their impacts on logistics performance in terms of customer service and cost leadership.

CONSTRUCT AND HYPOTHESES DEVELOPMENT

The lack of theoretical development and application in logistics research has been highlighted numerous times (Stock, 1996; Mentzer and Khan 1995; Olavarrieta and Ellinger 1997; Larsen 1999) but our understanding of logistics resources is still limited. Recently, there is an increased application of the resource-based view (RBV) theory for understanding LSPs (Lowson, 2003; Lai 2004; Panayides, 2004; Ellinger *et al.*, 2008; Yang *et al.*, 2009). Rooted in the strategic management literature, the RBV theory of the firm (Penrose, 1959; Wernerfelt, 1984) is applied to understand the relationship between firm's resource and competitive performance. According to Barney (1991), resources which are valuable, rare, inimitable, and non-substitutable are determinants of a firm performance. Since every LSP is different (heterogeneous) from other providers in terms of resources they acquired, no two LSPs will possess the same capability, or access to the same assets, or build the same organizational routines. These differences will differentiate one LSP from another. Thus, we believe that the RBV theory will enhance the understanding of logistic resources and their impacts on LSPs' logistics performance.

In an attempt to understand strategic logistics resources, we have conducted a review of related literature. We found no agreement on what constitutes the total resources required by a LSP. For example, Larsen (2000) includes access to information (IT), service improvement and human capital as logistics resources. However, Lai (2004) divided logistics resources into tangible resources (e.g. warehouse, EDI linkage, fleets, and hardware), intangible resources (e.g. organizational process, skill, know-how) and capability (the ability of LSPs to create or deploy resources). Furthermore, a more complete list of resources is concluded by a recent study of 15 international LSPs; these resources are physical, information, human, knowledge and relational resources (Wong and Karia, 2010). Another issue is that, in the strategy and logistics literature, there are many different opinions about the conceptualization of resources. Terms such as "resource", "competence", and "capability" have been applied; some scholars do not differentiate them but some said that they are different from one another. In this paper, we believe that all the above elements, be it tangible or intangible (Lai, 2004), as long as they have an impact on the LSPs' performance, should be considered logistics resources and capabilities. Based on the theoretical grounds and an initial interview we developed the following constructs of logistics resources called resource-based logistics (RBL).

Technology resources are regarded as firms' ability to provide relevant technology and maintenance resources which enable communication, transmission and processing of information, for example, hardware, software (EDI, bar coding or IT solution), peripheral and communication system (Alshawi, 2001; Aldin, 2004). Technology resources (information technology, IT) have emerged as a strategic resource in explaining logistics performance of LSPs (e.g. Chiu, 1995; Hammant, 1995; Alshawi, 2001; Aldin *et al.*, 2004; Lai *et al.*, 2005; Sanders and Premus, 2005; Brah and Lim, 2006). Such technology-based resources are important for LSPs to acquire, process and transmit information for more effective decision making (Sander and Premus 2005) and enable information to be accessed and used by various parties in the logistic network to increase enhanced logistics performance (Brah and Lim 2006). Further there is a positive significant relationship between IT and logistics performance (Shang and Marlow, 2005). Thus the use of technology is valuable to LSPs by reducing costs and; increasing productivity and customer services (Lai, 2004; Lai *et al.*, 2005; Karia and Razak, 2007). Hence we propose hypothesis 1: the higher the level of technology resource the greater is the logistics performance in term of (a) customer service innovation and (b) cost leadership.

Physical resources are regarded as firms' ability to provide logistics equipment and facilities as well as continuous adaptation and innovations in physical resource. Previous studies demonstrated that physical resources are positively related with performance (Penrose, 1959, Wernerfelt, 1984; Persson and Virum, 2001; Facanha and Horvath, 2005). For example transport vehicles and warehouses are required for the movement of inventory resources such as raw material, work in process, or finished goods (Closs and Thompson, 1992; Karia and Razak, 2007). Since physical resources are one of the most critical resources for LSPs, it is important to gain access to these resources to maintain the control of logistics activity and to improve the reliability and speed of delivery (Karia and Razak, 2007; Wong and Karia, 2010). They are valuable to perform various movements of goods and become costly to imitate due to the need for high capital investments. Advance physical resources (e.g. advance system, EDI computerized network, web-based information) have also been suggested not only to enhance control over logistics activity, save cost and improve delivery performance as well as customer satisfaction (Olavarrieta and Ellinger, 1997). Hence we propose hypothesis 2: the higher the level of physical resource the greater is the logistics performance in term of (a) customer service innovation and (b) cost leadership.

Relational resources are regarded as firm competence in building relationship with customers and suppliers which facilitates communication (La Londe and master 1994), coordination/collaboration (La Londe and master 1994; Larson and Kulchitsky 1999), and commitment in information sharing (Chen and Paulraj 2004). Relational resources have been argued as one of the key success factors for LSPs (e.g. Chiu, 1995; Gunasekaran and Ngai, 2003; Panayides and So, 2005; Panayides, 2007; Karia and Razak, 2007). They are the fundamental to logistics business which require the users and providers jointly plan, execute and co-ordinate to confirm networking and to provide understanding so that it reduce cost, improve customer service and service innovation (Brewer and Speh, 2000; Mentzer et al., 2000; Karia and Razak, 2007). Panayides and So (2005) found firm collaboration to have positive impact on performance. Hence, we propose hypothesis 3: the higher the level of relational resource the greater is the logistics performance in term of (a) customer service innovation and (b) cost leadership.

Organizational resources are regarded as firms' competence in the development of system, routines, policies, business process and ways of doing things, which may have positive impact on strategy and objective of a firm (Hofer and Schendel, 1978, Tomer, 1987; Grant 1991). Organizational resources are argued as a key success factor for LPSs (Panayides, 2007; Karia and Razak, 2007; Wong and Karia, 2010). In a logistics business, organizational resources include management practices (Brah and Lim 2006; Ellinger et al., 2008), planning and control systems (Lowson 2003; Gunasekaran and Ngai, 2003), and the culture of the firm (Sink, 1996; Aldin 2004) are essential in reaching customer and providing superior level of service. Brah and Lim's (2006) study on the relationship between quality practices (TQM) and performance of 81 LPSs found that TQM has a positive correlation with performance. Plenty of logistics literature suggested that organizational resources synthesize the strategy and objective of LPS's into practices to provide innovative service and cost leadership (e.g. Chiu 1995; Daugherty and Pittman, 1995; Ellinger et al., 2008). Indeed organizational resources not only improve service quality, but create more sustainable service and gain superior performance (Aldin, 2004). Hence we propose hypothesis 4: the higher the level of organizational resource the greater is the logistics performance in term of (a) customer service innovation and (b) cost leadership.

Management expertise resources are regarded as firm ability to acquire and develop skilled people and integrated teams with technical, knowledge and experienced (Penrose, 1959, Rueber, 1997). In the competitive world, management expertise resources are crucial for LSPs performance (Lai et al., 2005). It is essential (Prahalad and Hamel, 1990) to inspire trust and confidence which lead to quick service and performance (Hunt, 2001). Management commitment is important in deploying strategy in human resources (Chiu, 1995; Larsen 2000) in order to have better trained employee and to change attitudes of managers to operate in new competitive environments (Larsen 2000; Lowson 2003). LSPs with a higher level of management expertise will attain greater logistics performance as it may affect cost, quality, responsiveness and customer satisfaction (Karia and Razak 2007; Wong and Karia 2009). For example Wright et al., (1995) found that firm exhibited higher performance when they recruited and acquired competence employees. Hence we propose hypothesis 5: the higher the level of management expertise the greater is the logistics performance in term of (a) customer service innovation and (b) cost leadership.

In summary, resource-based logistics (RBL) may be considered as a capability which is acquired, provided and developed by a LSP. More formally, a LSP's RBL is made up of tangible and intangible resources (Grant 1991; Hunt, 2001). More specifically the tangible logistics resources are captured by technology resources and physical resources (Persson and Virum, 2001; Lai, 2004); and the intangible logistics resources are captured by relational resources (Panayides and So, 2005; Panayides, 2007), management expertise resources (Larsen 2000; Lai et al., 2005) and organizational resources (Brah and Lim 2006; Ellinger et al., 2008).

METHODOLOGY

A pilot study based on semi-structured interviews with eight informants from seven logistics companies was conducted to establish constructs and the measures of RBL components and to develop a survey questionnaire. Then the questionnaire was pre-tested by consulting ten experts' and adjusted accordingly to avoid confusion and to enhance understanding of questionnaire. Then the survey questionnaire was sent to 354 Malaysian's LSPs. Of these there were 123 usable questionnaires, with a response rate of 35 percent. Subsequently an independent-sample t-test is performed to 30 items of RBL. Overall there were no significant differences ($p>0.1$) were found between early and late respondents in all the 30 items. Further the comparison between the early and late respondents in key constructs including firm size, firm status (ownership), and business duration were conducted using t-test. The results shown no significant differences between these two groups in term of any of the three measures (for firm size: $p=.760$, firm status: $p=0.498$, duration of business: $p=0.435$). Therefore, non-response bias was not expected to be a serious problem.

Sample profile

Our samples are chosen from integrated logistics providers which perform part or full of logistics service. Approximately half (51 percent) of LSPs were the fully Malaysian-owned companies and another half were Malaysia-owned (49 percent). There were almost equal firm's representations in firm size. Slightly more than half (53 percent) of the LSPs had been in the industry for more than 15 years, reflecting the stability of logistics industry in Malaysia, with an average of 20 years and a standard deviation of 15 years.

RESULTS AND EMPIRICAL ANALYSIS

Exploratory factor analysis

Exploratory factors analysis was applied to confirm the components of RBL. We anticipated that RBL components are made up of tangible and intangible resources as theorized by RBV theory (Grant 1991; Hunt 2001), thus factor analyses are performed to understand the underlying dimensions of tangible and intangible resources and to reduce the irrelevant items. After loading, 4 items: product identification system; management and leadership training; recruited educated workers and environmental policy items were dropped out. More specifically the tangible resource is captured as two separate independent variables which are advance physical resources and technology resources; intangible resources made up of three separate independent variables, which are organization, relational and managerial expertise resources. Furthermore, logistics performance is divided into two separate dimensions, which are customer service innovation and cost leadership. Each of these constructs had Cronbach's alpha above .70, Eigen values above 1 and variance explained above 16 percents (refer to Table I, II and III). So we concluded that these five RBL components are not co-varied.

Tangible resource attributes	Factor 1	Factor 2
Advance physical resource		
Look for new or technology advance equipments	**.789**	
Acquire web-base information system	**.749**	
Acquire advance equipments	**.739**	
Acquire improvement in facilities	**.633**	
Acquire improvement in technology usage	**.627**	
Technology resource		
Provide basic communication tools		**.829**
Provide software and computer system		**.686**
Provide frequent maintenances		**.638**
Provide logistic facility/equipment		**.633**
Eigenvalue	3.19	2.64
% of variance	31.88	26.42
Cronbach's alpha	.82	.75

Table I: Results of the principle component analysis for tangible resource

Intangible resource attributes	Factor 1	Factor 2	Factor 3
Organizational Resource			
communication with business partner	**.826**		
Focus on customer requirement	**.761**		
solution to customers	**.738**		
informal interaction with business partners	**.726**		
Able to achieve customer satisfaction	**.604**		
Establish trust and commitment with business partners	**.567**		
Management Expertise Resource			
Recruit experienced workers from the same industry		**.792**	
Provide IT training to upgrade logistics workers		**.610**	
Employ multi-experienced workers		**.567**	
Recruit logistics professional executives (expert in particular job/function)		**.542**	
Relational Resource			
Establish coordination/collaboration with business partner			**.845**
Commit to share information amongst business partners			**.626**
Require staff with good communication skill			**.592**
Eigenvalue	3.65	2.68	2.56
% of variance	22.80	16.76	15.99
Cronbach's alpha	.85	.76	.70

Table II: Results of the principle component analysis for intangible resource

Logistics performance attributes	Factor 1	Factor 2
Customer Service Innovation		
Better services	**.855**	
Greater % of on time delivery	**.826**	
Quicker responses to customers	**.808**	
More unique solution	**.807**	
More satisfied with the service level	**.770**	
More additional service	**.738**	
Cost		
Lower equipments cost	.234	**.887**
Lower distribution cost	.234	**.873**
Eigenvalue	4.39	2.18
% of variance	48.73	24.19
Cronbach's alpha	.92	.82

Table III: Results of the principle component analysis for logistics performance

Regression analysis

Linear regression analysis was conducted to test the relationship between each RBL and LSP's performance. The R-squares (R^2) show how much the variance of logistics performance can be explained by each RBL. The results indicate that technology, physical, relational, organizational and management expertise resources were able to explain about 10% to 29% of variance in customer service innovation; and 9% to 20% of variance in cost leadership (p=0.001 to 0.000). The positive coefficients suggest positive associations between each RBL and logistics performance, supporting all hypotheses (H1-H5). Note that the *F*-value in Table IV are significant (p=0.001 to 0.0001) for the two logistics performance dimensions, suggesting that the associations between each RBL and logistics performance were significant at 95% confidence level.

The impact of technology on performance measure (H1)

Independent Variable	Customer service innovative	Cost leadership
Intercept	2.32****	1.91****
Technology	**.40********	**.40*******
R^2	.15	.09
F	20.51	11.59

The impact of advance physical resource on performance measure (H2)

Independent Variable	Customer service innovation	Cost leadership
Intercept	2.03****	1.97****
Advance physical	**.49********	**.403********
R^2	.26	.10
F	41.25	13.93

The impact of relational resource on performance measure (H3)

Independent Variable	Customer service innovation	Cost leadership
Intercept	2.71****	1.95****
Relational	**.33********	**.411********
R^2	.10	.10
F	13.72	13.35

The impact of organizational resource on performance measure (H4)

Independent Variable	Customer service innovation	Cost leadership
Intercept	1.38****	.77
Organizational	**.63********	**.67********

R^2	.29	.20
F	48.67	30.30

The impact of management expertise resource on performance measure (H5)

Independent Variable	Customer service innovation	Cost leadership
Intercept	2.30****	1.80****
Management expertise	**.442******	**.464******
R^2	.20	.14
F	30.63	19.00

****.Significant at the 0.000; ***.Significant at the 0.001; **.Significant at the 0.005

Table IV: Result of the relationship between RBL and logistics performance

DISCUSSION

The above findings contribute to the logistics literature on how both tangible and intangible logistics resources are constructed and measured. The tangible elements of RBL include physical logistics equipments and technology system (hardware and software) as well as advanced equipments and strong technology supports. In addition, the three intangible elements of RBL are organizational, relational and management expertise resources. These constructs are supported by the RBV theory which divides resources into tangible and intangible (Grant 1991; Hunt, 2001; Lai 2004).

The findings show that LSPs acquired a high degree of firm-specific RBL to achieve greater logistics performance in term of customer service innovation and cost leadership. However, the performance effects of each RBL vary. Specifically, the tangible resources in term of technology and physical resources have positive and significant associations with customer service innovation and cost leadership. Technology resources enable information to be accessed and used by LSPs and customers would support logistics operations in deliver customer service innovation and cost leadership (competitive advantage). Similarly physical resources are important tangible resources which give greater impact on logistics performance. These findings support previous studies (Brah and Lim 2006; Shang and Marlow, 2005, Penrose, 1959, Wernerfelt, 1984; Facanha and Horvath, 2005) that tangible resources positively related to performance. Furthermore, the intangible elements of resource namely relational, organizational and management expertise resources have positive and significant associations with customer service innovation and cost leadership. Relational resources facilitate networking and allow for more collaboration to provide better understanding and value to a LSP (Brewer and Speh 2000; Mentzer et al., 2000). Similarly, organizational resources synthesise firm's strategy and objective to achieve high level of customer service innovation and cost leadership. These findings are consistent with some previous studies (Brah and Lim, 2006; Karia and Razak, 2007; Ellinger et al., 2008). Further management expertise resources have significant associations with LSP performance. The results support Reuber's (1997) argument, that in the competitive world, LSPs should focus more on the management expertise resources as the best people able to transform their skill, experience, knowledge/ability into high logistics performance.

CONCLUSION

This research provides insights into the nature of logistics resources acquired in Malaysian LSPs. Five RBL constructs and their measures were identified, established and tested and they were positively associated with logistics performance. This paper contributes to the development of the constructs of logistics resources, and further provides empirical evidences that indicate how each RBL explains LSPs performance. The above results showed that LSPs should focus on developing capabilities in the five RBLs; LSPs should develop advanced equipments or technology, ability to adapt and innovate in human capital, technological, relational and organizational resources to meet with customer demands of unpredictable changes. Surely, this study has several limitations. There might be some deficiencies in the measurement of various key constructs because reliable objective measures of these constructs have not yet been fully developed. Of particular concern is the way management expertise resources are operationally defined and measured, as there still a scarcity of empirical studies in this particular area. Similar concern is in distinguishing organizational resources as apposed to logistics performance. Subsequent studies must reconfirm and validate the operationalisation of these constructs. Furthermore, future research should examine the potential combined effects (bundling) of several logistics resources on logistics performance.

REFERENCES

Aldin, N., Brehmer, P., & Johanson, A. (2004) "Business development with electronic commerce: refinement and repositioning", *Business Process Management Journal*, 10(1), 44-62.

Alshawi, S. (2001) "Logistics in the internet age: towards a holistics information and processes picture", *Logistics Information Management , 14* (4), 235-241.

Barney, J. (1991) "Firm resources and sustained competitive advantage", *Journal of Management , 17* (1), 99-120.

Brah, S. A., & Lim, H. Y. (2006) „The effect of technology and TQM on the performance of logistics companies", *International Journal of Physical Distribution & Logistics Management , 36* (3), 192-209.

Brewer, P. C., & Speh, T. W. (2000) "Using the bakance score card to measure supply chain performance", *Journal of Business Logistics , 21* (1), 75-94.

Chen, I. J., & Paulraj, A. (2004) "Towards a theory of supply chain management: the constructs and measurements", *Journal of Operations Management , 22*, 119-150.

Chiu, H. N. (1995) "The integrated logistics management system: a framework and case study", *International Journal of Physical Distribution & Logistics Management , 25* (6), 4-19.

Closs, D. J., & Thompson, C. K. (1992) "Logistics physical resource management", *Journal of Business Logistics , 13* (2), 269-283.

Daugherty, P. J., & Pittman, P. H. (1995) "Utilization of time-based startegies: creating distribution flexibility/responsivenss", *International Journal of Operations & Production Management , 15* (2), 54-60.

Ellinger, A. E., Ketchen, D. J., Hult, G. T., Elmadag, A. B., & Richey, R. G. (2008) "Market orientation, employee development practices, and performance in logistics service provider firms" *Indusrtrial Marketing Management , 37*, 353-366.

Facanha, C., & Horvath, A. (2005) "Environment assessment of logistics outsourcing", *Journal of Management in Engineering, 21* (1), 27-37.

Gunasekaran, A., & Ngai, E. W. (2003) "The successful management of a small logistics company", *International Journal of Physical Distribution & Logistics Management , 33* (9), 825-842.

Grant, R. M. (1991) "The resource-based theory of competitive advantage", *California Management Review , 33* (3), 114-135.

Hammant, J. (1995) "Information technology trends in logistics" *Logistics Information Management , 8* (6), 32-37.

Hunt, S. D. (2001) "Commentary - a general theory of competition: issues, answer and an invitation", *European Journal of Marketing , 35* (5/6), 524-548.

Hofer, C.W., Sandberg, W., (1987) "Improving new venture performance: some guidelines for success", *American Journal of Small Business*, 12(1), 11–25.

Karia, N., & Razak, R. C. (2007) Logistics asets that payoff competitive advantage. In K. S. Soliman, *Information Management in the Networked Economy: Issues & Solutions* (pp. 33-39). New York: International Business Information Mangement Association.

La Londe, B. J., & Master, J. M. (1994) "Emerging logistics strategies: blueprints for the next century", *International Journal of Physical Distribution & Logistics Management , 24* (7), 35-47.

Lai, K. H., Ngai, E. W., & Cheng, T. C. (2005) "Information technology adoption in Hong Kong's logistics industry", *Transportation Journal , 44*(4), 1-9.

Lai, K. (2004) “Service capability and performance of logistics service providers”, *Transportation Research Part E , 40*, 385-399.

Larsen, T. S. (1999) “Supply chain management: a new challenge for reseachers and managers in logisitcs”, *The international Journal of Logistics Management , 10*(2), 41-53.

Larsen, T. S. (2000) “Third party logistics - from an interorganizational point of view”, *International Jpurnal of Physical Distribution & Logistics Management , 30*(2), 112-127.

Larson, P. D., & Kulchitsky, J. D. (1999) “Logistics improvement programs: the dynamics between people and performance”, *International Journal of Physical Distribution & Logistics Management , 29*(2), 88-102.

Lowson, R. H. (2003) “How supply network operations strategies evolve: composition, competitive priorities and customisation”, *International Journal of Physical Distribution & Logistics Management, 33*(1), 75-91.

Mentzer, J. T., & Kahn, K. B. (1995) “A framework of logistics research”, *Journal of Business Logistics , 16*(1), 232.

Mentzer, J. T., Foggin, J. H., & Golicic, S. L. (2000) “Collaboration: The enablers, impediments and benefits”, *Supply Chain management Review , 4*(4), 52-58.

Olavarrieta, S., & Ellinger, A. E. (1997) “Resource-based theory and strategic logistics reserach”, *International Journal of Physical Distribution & Logistics Management, 27*(9/10), 559-587.

Panayides, P. M. (2007) “Effects of organizational learning in third-party logistics”, *Journal of Business Logistics, 28*(2), 133-158.

Panayides, P. M. (2004) “Logistics service providers: an empirical study of marketing strategies and company performance”, *International Journal of Logistics: Research and Applications , 7* (1), 1-15.

Panayides, P. M., & So, M. (2005) “The impact of integrated logistics relationships on third-party logistics serive quality and performance”, *Maritime Economics & Logistics , 7*, 36-55.

Penrose, E. T. (1959). *The Theory of the Growth of the Firm.* New York: John Wiley.

Persson, G., & Virum, H. (2001) “Growth strategies for logistics service provider: A case study”, *International Journal of Logistics Management, 12*(1), 53-64.

Prahalad, C. K., & Hamel, G. (1990) “The core competence of the corporation”, *Harvard Business Review, 68*, 79-91.

Reuber, R. (1997) “Management experience and management expertise”, *Decision Support System 21*, 51-60.

Sanders, N.R., & Premus, R. (2005) “Modeling the relationship between firm IT capability, collaboration and performance”, *Journal of Business Logistics, 26*(1), 1-23.

Shang, K. C., & Marlow, P. B. (2005) “Logistics capabilities and performance in Taiwan's major manufactuirng firms” *Transportation Research Part E , 41*, 217-234.

Sink, H. L., Langley, C. J., & Gibson, B. J. (1996) “Buyer observations of the US third-party logistics market” *International Journal of Physical Distribution & Logistics Management, 26* (3), 38-46.

Stock, J.R. (1997) “Applying theories from other disciplines to logistics”, *International Journal of Physical Distribution & Logistics , 27*(9/10), 515-539.

Wernefelt, B. (1984) “A resource-based view of the firm”, *Strategic Management Journal, 5*(2), 171-180.

Tomer, J.F., (1987) *Organizational Capital*, Praeger, New York.

Wong, C.Y., and Karia, N., (2010) “Explaining the competitive advantage of logistics service providers: a resource-based view approach”, *International Journal of Production Economics*, in press doi:10.1016/j.ijpe.2009.08.026.

Yang, C. C., Marlow, P. B., & Lu, C. S. (2009) “Assessing resources, logistics service capabilities, innovation capabilities and the performance of container shipping service in Taiwan”, *International Journal of Production Economics, 122*, 4-20.

INNOVATION CAPABILITIES OF LOGISTICS SERVICE PROVIDERS- AN INVESTIGATION OF DRIVERS FOR INNOVATION

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INTRODUCTION

The market for logistics services is characterized by changing customer demands regarding quality and higher service levels (Wagner 2008) (e.g. just-in-time delivery). An increasing number of customers requests for new and valuable services (for instance the provision of real-time data by using of Tracking & Tracing Systems (Arndt 2008)). Therefore, the competitiveness of Logistics Service Provider (LSP) depends on their ability to adapt their offered services to changing customer demands (Pfeiffer 2008). One general way to cope with changing customer demands and to ensure a company's competitiveness (Brockhoff 1996) can be innovations. Thereby, innovations can be understood as ideas, concepts, and practices to improve products as well as processes (Rogers 2003).

If the improved products and processes are recognized as new and valuable by customers the innovations can lead to an increasing quality of the companies' service portfolio (Pfohl, Köhler & Röth 2008). A higher service level can have significant effects on a company's options for its positioning and differentiation from competitors and therewith on its corporate value (Song, Thieme 2006; Chapman, Hyland 2004). In conclusion, innovations can be seen as a key factor for economical growth and competitiveness (Pfohl, Köhler & Röth 2008) Thus, the competitiveness of LSP is related to their ability to be innovative (Wagner 2008). Hence, the question arises how LSP can increase their innovation capability. *Flint et al.* (2005) as well as *Wagner* state that in logistics research this question has been nearly ignored up to now (Flint et al. 2005; Wagner 2008).

Therefore, the overarching objective of this paper is to identify drivers of innovation capabilities for LSP in order to provide the logistics innovation management with an approach to develop and control its success factors. Hence, the objectives of the paper are threefold: Firstly, the paper aims for a comprehensive description of innovation and innovation capability in logistics. Furthermore, the paper intends to generally analyze potential drivers, which influence the innovation capability of a company. Finally, the paper will discuss hypotheses regarding the importance of changing customer demands and different drivers of innovations for LSPs.

Consequently, the paper will be structured as follows: In the second section, the innovation capability of LSPs will be characterized in order to deduce resulting deficits regarding their innovativeness. In the third section, drivers affecting the innovation capability of companies will be generally described by a broad review of innovation management literature. In section four, the identified drivers of innovation shall be adapted to specific conditions of the logistics context by a hypotheses discussing approach. The paper will conclude with a summary of the main findings.

SOME THOUGHTS ON LACK OF INNOVATIONS IN LOGISTICS

Specificity of Logistics Markets – Some 'Megatrends'

According to the Council of Logistics Management (2010) the term logistics can be defined as *"that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements"* (CLM).

Especially through worldwide progress and changes (e.g. open boundaries), a lot of industries are highly confronted with different drivers, which lead to new challenges and therewith to new requirements for the actors. These new challenges, which are often called megatrends, also exist and are investigated for the special case of logistics. *Arndt* (2008) lists among others **globalization, increasing customer demands**, and shortening **product-life-cycles** as these megatrends (Arndt 2008). *Klaus & Kille (2008, 2009)* also mention arising options for LSP caused by **technological progress** as well as **increased environmental sensibility** of customers (Klaus, Kille 2008/ 2009). These megatrends are also connected to different market changes, which constitute new conditions for LSP and lead to new challenges. Moreover, not only the increasing customer demands but also the other mentioned megatrends lead to new challenges due to a change in customer demands for LSP. That shall be described as follows: According to *Arndt* (2008), **globalization** leads to an increasing demand for services due to new customers as well as to an increase in market rivalry based on market entries of new competitors. The eastern European expansion of the EU is one example for this development, since the open boarders lead to new potential customers from other countries but also to new competitors on the own markets. An **increase of customer demands** is mentioned as another megatrend and results from the fact that new competitors on the markets lead to more options for the customer in choosing a LSP as well as to an increased market rivalry for the providers. Thus, a customer can increase his demands towards an outstanding quality of services, since he can choose between more providers offering the best service for him. Since customers are aware of the rivalry between the LSPs they can also expect low prices for services. The length of **product-life-cycles** is the time between introducing a new product to a market and the replacement by the next new product. Thus, it is directly related to the duration in which a product or a service can generate profits for a company. The life-cycle is influenced by changing demands of end customers, since the duration in which a product can generate profits depends on the behavior of the end-customer in buying the product (e.g. fashion depends on customer perception and becomes obsolete very fast). These shorter product-life-cycles lead to a change in the customer demands of the LSPs regarding adequate (fast but also cheap) solutions, resulting directly in new challenges for them. Thus, LSP have to adapt their transport services to these requirements (e.g. fashion has to be transported by plane since a ship transport lasts too long) (Arndt 2008). *Klaus & Kille* (2008, 2009) also mention **technological progress** triggered by the availability of new information and communication technologies as well as augmented use of handling technologies like RFID (Radio Frequency Identification) as logistical trends (Klaus, Kille 2008/2009). This technological development can result in new products and improved processes but also in the necessity for LSP to adapt to new technological standards (e.g. RFID in Supply Networks requires the use of RFID by all embedded Service Providers in order to handle the material and information flow). The LSPs adoption to technological change can also be triggered by a customer himself. That means that the customer can demand for a product or service, which bases on the technological progress (e.g. if the customer is aware of the "Tracking & Tracing System's" existence he can demand for it). The **environmental sensibility** of customers as well as political systems leads to a further megatrend in logistics. Customers are more and more demanding for "Greener" products and processes whish also results from the sensibility of their own customers/ end-customers (e.g. CO_2 Footprint for products). Moreover, governments have become more sensible regarding environmental topics, which leads to additional laws and requirements (e.g. emission trade) (Klaus, Kille 2008/ 2009).

In summary, each of the mentioned megatrends leads to an increase of customer demands. A successful fulfillment of these changing demands requires a changed focus on innovations for LSP in order to cope with the resulting challenges.

General Importance of Innovation Capability

According to *Ibrahim and Fallah* (2005), innovations can be regarded as a driver for a creation and maintenance of competitive advantages and economic growth (Ibrahim, Fallah 2005). One reason for the necessity of innovations lies in today's competitive challenges, like rapid pace and unforeseeable technological change that companies have to cope with (Betz 1997). That means that innovations can lead to flexibility in order to fit customer demands in rapid changing environments and technological advance regarding competitors. Therefore, companies, which are able to manage innovation in an adequate way, can gain success in comparison to competitors (Antoniou, Ansoff 2004). However, there is no common understanding and definition of innovation and innovation capability in the literature (Chieh-Yu Lin 2006). This research shall base on the approach of *Afuah* (2003), who states that an innovation is "*the use of new technical and administrative knowledge to offer a new product or service to customers. The product or service is new in that its cost is lower, its attributes are improved, it now has attributes it never had before, or it never existed in that market before"* (Afuah 2003). Following this, the innovation capability of a company can be described as company's ability to fulfill the prerequisites for a successful innovation process in order to generate new products or services. The process of technological innovation can either focus on the creation of new products (product innovations) or on the improvement of production processes (process innovation) (Auerswald, Kulkarni 2008). With recourse to *Ibrahim, Fallah* (2005), this paper works under the assumption that being innovative is a precondition for market success and obtaining competitive advantages.

Importance of Innovation Capability in Logistics

The changing customer demands require new services as well as improved processes to decrease costs and permit lower prices. In order to cope with the increasing customer needs regarding value adding services to low prices, innovations in services and improved processes are required as well. Changing life-cycles for products also require offering new services, which fulfill the customer demands (e.g. faster transportation services through optimization). The technological progress also enables innovation especially in new technologies in order to adopt to new industry standards (RFID in supply chain networks) or in improved processes (e.g. autonomous estimation of good conditions by sensor networks) in order to fit customer demands for value adding services (e.g. measuring good conditions during the container transport). The demand for "greener logistics" can also be faced by innovations in improved services (e.g. optimizations and measurement of CO_2 emissions), which can result in new services (offering CO_2 footprint for service) and which can base on the use of new technologies (e.g. highly efficient engines).

However, former research in the area of innovation has shown that low innovation expenditure is related to a low innovation capability (Mairesse, Mohnen 2001). An indicator for the extent of innovative activities is the innovation intensity, which describes the ratio between the total volume of innovation expenditure and the total revenue of all firms. It accounts for 2,1% in the market for transportation logistics in Germany in comparison to 8,5% in the German vehicle construction and 6,9% in the software and telecommunication industry (Wagner 2008). This low ratio shows a lack of innovation projects (new services or processes) in the logistics industry. Moreover, due to this low ratio of innovation expenditure a lack of innovation capability in the market for logistics services might be assumed. Thus, it might also be assumed that logistics companies are not able to fulfill the prerequisites for a successful innovation process in order to generate new products or services. Accordingly, this leads to the question how the innovation capability of LSPs can be increased in order to launch innovation projects and cope with the new customer demands, arising from the megatrends. To answer this question general drivers for the increase of a company's innovation capability in order to activate innovation projects shall be discussed as follows.

GENERAL DRIVERS FOR INNOVATION CAPABILITY

Innovations have been discussed regarding their possible drivers in several investigations in which different drivers have been identified. During the CIMA (Euro-Australian co-operation centre for Continuous improvement and innovation Management) research project, which should facilitate the transfer of knowledge respectively technology between European and Australian organizations (Boer et al. 2001), different categories of possible drivers for innovations have been identified. These categories are:

- available knowledge and information,
- performance measurement,
- human resource management systems,
- organizational structures,
- project planning and control,
- and technology (Soosay, Hyland 2004).

Since these categories provide a comprehensive overview including drivers from other research projects they shall be used as a basis for this investigation.

According to *Soosay & Hyland* (2004), the categories can be described as follows: **Available knowledge and information** means the relevant information and knowledge base a company has gained regarding customers, competitors or the application of processes. The gained knowledge can be used to improve organizational functions and to apply it in an innovative way, what can result in an improvement of fitting customer demands or competing with competitors. The knowledge and information can be gained by two different ways. On the one hand, the knowledge can base on information acquired from customers and suppliers, which is generated by the internal staff. On the other hand it can be gained by recruiting competitors' staff.

Performance measurement estimates the outcomes (e.g. of an investment) proportional to the input and is also transferable to the evaluation of innovation projects. In the context of innovations, one way can be to monitor improvements after innovative approaches in order to intervene if the current outcomes do not fit to the plan (Goh, Richards 1997). One possible indicator might be the financial position, which can be used to measure the effect of innovation regarding potentials of decreasing costs or respectively improving profits.

Human resource management (HRM) systems constitute the third category of innovation drivers and describe systems dealing with human resources regarding the acquisition, assessment, and development of human resources in an adequate manner (Klaus, Kille 2008/ 2009). Regarding innovations, it can assure the process of gaining new knowledge and new ideas within the organization by the recruitment of new members as well as by the motivation of current staff to bring in their ideas. Thus, the HRM can provide creative capacity for the company, which in turn can lead to innovations (Crossan, Lane & White 1999). An adequate HRM includes the structuring of working teams, human resource development as well as the recruitment of new staff.

The HRM is narrowly related to the next category, the **organizational structures** of the company, since the effective application of human capital requires adequate structures of the whole company. The organizational structures can affect innovations by driving knowledge distribution and learning. The learning process can lead to improvements in processes and therewith to better or rather new products. Thus, internal structures like temporary or cross-functional teams can enhance knowledge distribution and learning within a company.

The fifth category is **project planning and control**. This includes procedures and protocols, which are important for driving a project in the before planned way. Thereby, it can also drive innovation into the right and former fixed direction, since it sets the innovations direction and controls its progress (Cooper et al. 1999). That means that the start of an innovative project should also be accompanied by a procedure plan as well as control methods. Thus it becomes possible to identify variances and react by adopting the project.

Technology as the last category of drivers for innovations refers to the implementation of new technologies in order to improve services or processes (e.g. information and communication technologies can enhance processes like the collection of data and lead to fast and safe data transfer). Thereby, they can lead to innovations in services as well as related processes. That means that they can enable companies to offer new services which base on the use of new technologies or they can lead to more efficient processes which can result in lower costs for a company. However, as mentioned above, a technology can be implemented as a process of adaption to technological standards or can base on former market analysis regarding customers' demand. If customers ask for special products which require the use of innovative technologies those demands can also trigger the implementation of new technologies (Soosay, Hyland 2004).

The drivers, which were outlined in this section in general, shall be investigated regarding their connection to logistics in order to investigate how to increase the innovation capability of LSP. Therefore, it shall be analyzed how the increase of customer demands affects the importance of the drivers for Logistics Service Providers.

INNOVATION DRIVERS AND THEIR IMPORTANCE TO COPE WITH INCREASING CUSTOMER DEMANDS IN LOGISTICS

Increasing customer demands in logistics markets affect the most important drivers of the innovation capability of LSP in several ways. The importance of each of these drivers, in turn, seems to increase, which leads to the following hypotheses:

*Hypothesis 1: The more the customer demands are increasing the more important the **available knowledge and information** becomes for LSP in order to be innovative.*
With recourse to the introduced understanding of innovation capability as the ability to use new technical and administrative knowledge in order to offer a new product or service to customers (Windt, Hülsmann 2007), this hypothesis can be exemplified by three reasons. LSP need to know the alterations of the demands of their customers in order to be able to fulfill them by adapting their logistics services. Second, LSP need to know how to fulfill the current as well as future customer demands so as to be able to adapt their services in the right way. Third, LSP need to know how to constantly update the knowledge and information on which demands have to be fulfilled in which way. Since it can be assumed that the customer demands are changing permanently (Arndt 2008) the resource as well as the knowledge base has to be updated constantly. Hence, the more the customer demands are increasing the more important does it get to know which demands are increasing (e.g. value added services), how to fulfill them (e.g. by means of which resources, like vehicles or individuals) and how to constantly update this knowledge- and information base in order to be able to offer new logistics services that, in turn, fulfill the increasing customer demands.

*Hypothesis 2: The more the customer demands are increasing the more important the **performance measurement** becomes for LSP in order to be innovative.*
A change in customer demands can lead to the expectation of new service features or new services (e.g. storage in addition to transport). That means that services become obsolete and are not able to gain profits any longer (product-life-cycle). Moreover, the customer can expect lower prices for a service, since his option to choose between different suppliers leads to increased bargaining power. Thus, a LSP can be forced to change his services regarding features or costs through innovations in order to fit the

changing demands, what can lead to increasing costs for input (e.g. human resources, space for storage). Thus, innovation in services or processes can lead to high investments (e.g. new machines, new vehicles, storage space). Moreover, it is not sure to a degree of 100 percent to meet the customer demands by an innovation, since information regarding the demands can be incorrect what can in turn lead to unsuccessful innovation. Thereby, a risk for investments in innovation in order to fulfill customer demands can occur. Thus, a monitoring of the ratio between revenues and costs is of high relevance in order to avoid losses by the estimation of the cost structure of an implemented innovation project. Thereby, unsuccessful innovation projects, which bind resources (human beings, machine capacity) can be identified early in order to either close them or adopt them to changed requirements. Thus, the loss risk through unsuccessful innovation projects can be decreased.

Thus, the more innovation projects are implemented in order to fit the increasing customer demands the more an adequate performance measurement has to be considered.

Hypothesis 3: The more the customer demands are increasing the more important are the ***HRM systems*** *for LSP in order to be innovative.*
As mentioned above, increasing customer demands lead to an increase of the importance of the knowledge base for the innovation capabilities of LSPs. One important factor for gaining, maintaining, and sharing relevant knowledge regarding the characteristics of new and upcoming customer demands is the company’s human resource base. An adequate HRM System provides an organization with creative capacity that can lead to innovation (Crossan, Lane & White 1999). Beside the necessity to develop a human resource base that is capable of acquiring adequate managers and employees, the HRM systems of LSP are required to create on the one hand an organizational culture, which promotes innovative and creative thinking of the individuals and gaining relevant knowledge (e.g. setting of incentives for innovative suggestions and ideas of employees). On the other hand, the organizational structures have to reflect this necessity through for instance implementing special project teams for a monitoring of trends in logistics markets and possibilities how to fulfill current and upcoming customer demands.
Hence, a human resources-based creation of organizational cultures and structures are the more important the more rapidly the organizational environment – the customer demands – is changing, in order to gain and maintain a LSPs innovation capability.

Hypothesis 4: The more the customer demands are increasing the more important is the ***organizational structure*** *for LSP in order to be innovative.*
The more the customer demands are increasing the more important it becomes for LSP to learn how to cope with them. The degree to which an organization is able to learn is influenced beside others by its organizational structure. *Burmann* (2005) for instance shows that an organization’s learning ability can be maximized by balancing the organizational structure between centralized and decentralized decision-making (Burmann 2005). In associated literature on logistics, the degree of decentralization of decision-making is discussed in connection with autonomous co-operation as an organizational principle and associated technologies, such as RFID-tags or Sensor Networks (Gehrke et al. 2006). These technologies enable logistics agents to render their own decisions without asking a higher entity. Thus, they learn from their own decisions as well as the decisions of other agents since they get relevant information through interaction (Hülsmann, Cordes 2009). If decisions would only rendered by one entity (centralized) the learning ability would also be limited to only one agent. Thereby, decentralized decision making processes in logistics systems can lead to a higher rate of learning ability in the system. Hence, in the course of increasing customer demands the importance of logistics companies’ organizational structure increases due to its contribution to the companies’ learning abilities, which are necessary for being innovative.

*Hypothesis 5: The more the customer demands are increasing the more important is an adequate **project planning and control system** for LSP in order to be innovative.*
It seems likely that the complexity of logistics services as well as of innovation projects for alterations of these services might increase in the course of increasing customer demands. Customers demand either a higher quality of the services or lower costs. Finding and accomplishing associated solutions that enhance the service's quality without inappropriate cost increases or that are able to cut their costs without decreasing the quality requires an adequate planning and control of the respective innovation projects. One example are additional storage and distribution services of Service Providers for transport logistics that require a higher amount of information to be considered and handled (e.g. storage area and minimum durability). Being able to cope with this increasing complexity is therefore an essential requirement for LSPs to be innovative.

Thus, an adequate project planning and control system for innovation projects becomes more important for LSPs through increasing customer demands, since the systems must also be able to plan and control highly complex projects.

*Hypothesis 6: The more the customer demands are increasing the more important is an appropriate usage of **technologies** for LSPs in order to be innovative.*
One possibility to achieve service and process innovations in order to cope with increasing customer demands is the usage as well as the development of technologies. Autonomous co-operation technologies are part of logistics research in order to investigate them regarding their contributions for increasing the flexibility of logistics systems. Thereby, autonomous co-operation aims for the achievement of increased robustness and positive emergence by flexible coping with dynamics and complexity (Windt, Hülsmann 2007). Autonomous co-operation-based technologies like RFID tags or sensor networks for instance offer possibilities to LSP to flexibly react on environmental changes, such as customer demands (Wycisk 2009). Tracking and Tracing systems offer possibilities to satisfy the customers' demand for knowledge about their transported goods and for options for an intervention (Arnold 2008). On the contrary, the knowledge about an existence of certain technologies might lead to increasing customer demands regarding their usage. Customers know for instance about the possibilities of autonomous cooperation-based technologies and might demand for their usage and for an extension of their potentials. Both effects increase the importance of technologies for the innovation capabilities of LSPs.

Thus, technologies become more important for LSP in order to meet the increasing customer demands by services which base on the technologies implementation.
In summary, it can be stated that an increase in the demands of customers leads to a higher importance of innovation drivers for LSPs. That results from the fact that the requirements, which base on changing demands, are positively related to the drivers of innovation. Thus, focusing on innovation drivers can support logistics companies in facing the challenges triggered by the new customer demands.

CONCLUSION
Innovation Capabilities are important for a company's success but are often neglected especially from companies in logistics markets. Thus, this investigation investigated general drivers of innovation regarding their importance for LSPs in order to cope with increasing customer demands triggered by several megatrends in logistics. However, after pointing out an increasing importance of the drivers the question occurs how important the drivers are in comparison to each other and if a ranking is possible. Since this research did not base on empirical results this question could not be answered but can be a starting point for further research. Thus, an empirical study for the special case of LSPs would be required in order to estimate the degree of the drivers importance for the logistics industry.

REFERENCES

Afuah, A. 2003, *Innovation management : strategies, implementation, and profits,* Oxford Univ. Press, New York, NY [u.a.].

Antoniou, P.H. & Ansoff H.I. 2004, "Strategic Management of Technology", *Technology Analysis & Strategic Management,* vol. 16, no. 2, pp. 275-291.

Arndt, H. 2008, *Supply Chain Management : Optimierung logistischer Prozesse,* Gabler Verlag / GWV Fachverlage GmbH, Wiesbaden, Wiesbaden.

Arnold, D. 2008, *Handbuch Logistik,* Springer, Berlin [u.a.].

Auerswald, P. & Kulkarni, R. 2008, "Placing Innovation: an Approach to Identifying Emergent Technological Activity", *Economics of Innovation & New Technology,* vol. 17, no. 7, pp. 733-750.

Betz, F. (ed) 1997, *Managing Technological Innovation: Competitive Advantage from Change*, John Wiley & Sons, New York.

Boer, H., Caffyn, S., Corso, M., Coughlan, P., Gieskes, J., Magnusson, M., Pavesi, S. & Ronchi, S. 2001, "Knowledge and Continuous Innovation: The CIMA Methodology", *International Journal of Operations and Production Management,* vol. 21, no. 4, pp. 490-504.

Brockhoff, K. 1996, "Technology Management in the Company of the Future", *Technology Analysis & Strategic Management,* vol. 8, no. 2, pp. 175.

Burmann, C. 2005, *Management von Ad-hoc-Krisen : Grundlagen, Strategien, Erfolgsfaktoren,* Gabler, Wiesbaden.

Chapman, R. & Hyland, P. 2004, "Complexity and learning behaviors in product innovation", *Technovation,* vol. 24, no. 7.

Chieh-Yu Lin 2006, "Influencing Factors on the Innovation in Logistics Technologies for Logistics Service Providers in Taiwan", *Journal of American Academy of Business, Cambridge,* vol. 9, no. 2, pp. 257-263.

CLM *, Council of Logistics Management (CLM),* www.clml.org.

Cooper, R., Charlton, J., Roberst, C., Whitelock, J. & Souder, W. 1999, "New Product Development: Leadership and Learning. A comparison of of UK and US High-Technology Companies.", *International Journal of Continuous Engineering Education and Life-Long Learning,* vol. 9, no. 1, pp. 88-114.

Crossan, M.M., Lane, H.W. & White, R.E. 1999, "An Organizational Learning Framework: From Intuition to Institution", *Academy of Management Review,* vol. 24, no. 3.

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.

Gehrke, J.D., Behrens, C., Jedermann, R. & Kluge, E.M. 2006, "The Intelligent Container - Toward Autonomous Logistic Processes" in *KI 2006 Demo Presentations*Bremen, pp. 15-18.

Goh, S. & Richards, G. 1997, "Benchmarking the Learning Capability of Organizations", *European Management Journal,* vol. 15, no. 5.

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.

Ibrahim, S. & Fallah, M.H. 2005, "Drivers of Innovation and Influence of Technological Clusters", *Engineering Management Journal,* vol. 17, no. 3, pp. 33-41.

Klaus, P. & Kille, C. 2008/ 2009, *Die TOP 100 der Logistik - Marktgrößen, Marktsegmente und Marktführer in der Logistikdienstleistungswirtschaft,* , Bremen und Hamburg.

Mairesse, J. & Mohnen, P. 2001, "To Be or Not To Be Innovative: An Exercise in Measurement", .

Pfeiffer, K. 2008, "Zuverlässigkeit zählt", *Logistik heute,* , no. 11.

Pfohl, H.-., Köhler, H. & Röth, C. 2008, "Wert- und innovationsorientierte Logistik - Beitrag des Logistikmanagements zum Unternehmenserfolg" in *Das Beste der*

Logistik: Innovationen, Strategien, Umsetzungen, ed. H. Baumgarten, Springer, Berlin [u.a.], pp. 91-100.
Rogers, E.M. 2003, *Diffusion of innovations,* Free Press, New York, NY [u.a.].
Song, M. & Thieme, R.J. 2006, "A cross-national investigation of the R&D-marketing interface in the product innovation process", *Industrial Marketing Management,* vol. 35, no. 3.
Soosay, C.A. & Hyland, P.W. 2004, "Driving Innovation in Logistics: Case Studies in Distribution Centres", *Creativity & Innovation Management,* vol. 13, no. 1, pp. 41-51.
Wagner, S.M. 2008, "Innovation Management in the German Transportation Industry", *Journal of Business Logistics,* vol. 29, no. 2, pp. 215-231.
Windt, K. & Hülsmann, M. 2007, "Changing Paradigm in Logistics" in *Understanding Autonomous Co-operation and Control: The Impact of Autonomy on MAnagement, Information, Communication, and Material Flow*, eds. M. Hülsmann & K. Windt, Springer, Berlin, pp. 1-12.
Wycisk, C. 2009, *Flexibilität durch Selbststeuerung in logistischen Systemen : Entwicklung eines realoptionsbasierten Bewertungsmodells*, Gabler.

GLOBAL COMPETITIVENESS OF LOGISTICS INDUSTRY IN DEVELOPING COUNTRIES – A CONCEPTUAL MODEL AND PROPOSITIONS

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INTRODUCTION

Globalisation of markets is a phenomenon that has received much attention over the last 20 years. In 1997, the International Monetary Fund (IMF) described globalisation as 'the growing interdependence of countries worldwide through increasing volume and variety of cross-border transactions in goods and services, freer international capital flows, and more rapid and widespread diffusion of technology' (IMF, 1997). Since then, much has been debated both at societal/cultural and business levels.

Mattsson (2003) highlight the globalisation of markets and reorganisation of logistics structure are interdependent. It does not only bring changes in market structures, but also drives the significant growth of freight movement. This phenomenon has been apparent in the last 15 years when there has been relocation of factories from the developed world to Asia, South America and Eastern Europe to take advantage of the low-skilled cheap workforce in developing countries. As a result, more complex and lengthy supply chains have emerged, requiring more efficient logistics functions to move products to the main marketplaces. Thus, managing complexities associated with extended supply chain and achieving a high degree of network coordination among globally dispersed supply chain entities becomes fundamental issues impacting decision making among the managers of (Bhatnagar and Teo, 2009).

The global recession, which triggered the world's economy recently, has brought even more challenges to the policy makers as well as to businesses. Although the developing world seemed to be spared from the fallout of this crisis at the very beginning, however, many developing countries are now facing slumping demand for their export products, falling commodity prices and significant reduction in foreign investment and remittances. The global liquidity shortages also impacted access to finance (Schwab, 2009). Malaysia, as one of the developing countries, has also been significantly affected by the global turbulence. For the first six months in 2009, Malaysia's exports decreased 23.4% at RM250.53 billion as compared to the same period last year. Meanwhile, the imports have also declined by 26.3% to RM 191.3 billion as compared to the figures registered in 2008 (Department of Statistics, 2010). The performance has been affected by poor demand by the major trading countries as well as weaker purchasing power by the domestic consumers.

Several researchers realise that the focus on logistics and supply chain management would be an effective means to gain efficiencies and eliminate accumulating competitive pressures. Thus, this study intends to explore the dimensions influencing the global competitiveness of the logistics industry in developing countries by using Malaysia as a case.

BACKGROUND OF THE STUDY

Anderson (2009) stresses the importance of managers to continuously assess their strength in terms of unique skills and capabilities as these may offer comparative competitive advantage in markets. This is because the socio-cultural attributes, regulatory and legal structure, level of economic development and the availability of supporting administrative and physical infrastructure are different from the home market. They are encouraged to analyse these potential constraints and opportunities whether their company-specific skills and capabilities outweigh country-specific challenges before operating abroad.

Johanson and Mattsson (1988) describe globalisation of a firm as a highly internationalised firm increasing the integration of its activities and its resources between different geographical markets. Thus a firm globalises when it has already extended its activities to cover many markets and it has already penetrated several markets to the extent that it is no longer a marginal actor in those markets.

Porter (1985) emphasises the value chain concept, which is a crucial tool for analysing the sources of competitive advantage. Value chain analysis comprises disaggregation of a firm into its strategically relevant activities in order to understand the behaviour costs and the existing and potential sources of differentiation. A firm gains competitive advantage by performing these strategically important activities more cheaply or better than its competitors. Porter identifies five primary elements of the value chain – inbound logistics, operations, outbound logistics, marketing and sales, and service. While the four support/secondary activities are procurement, technology development, human resource development, and firm infrastructure. Bhatnagar and Teo (2009) highlight logistics management has often been described as the next frontier of competition. They identify inventory, transportation, information and facilities as four drivers of supply chain competitiveness. The managers need to deal with the trade-offs of these four drivers resulted from the challenges emerged from the extended supply chain and network coordination. The trade-offs for transportation is between high versus low usage of premium transportation mode as well as the transportation batch size, while for inventory between high and low levels of safety stock. The extent of centralisation and information infrastructure becomes the key issue in information while the number of facilities and the extent of consolidated versus uncoordinated deliveries are the issue in facilities. They also indicate that the competitive measures/indicators come from financial, operational and customer functions.

By using the value chain model (Porter, 1985), Siddiqui and Asghar (2008) elaborate the linkage between the value margin, productivity, and competitiveness. They stress that competitiveness is measured from the value margin (value/cost ratio), which is equivalent to productivity, i.e. output/input ratio. They underline those inter-sectoral linkages between services and manufacturing that have always been disassociated from the economic policy framework of developing economies. It is because "the two sectors are largely seen as substitutes rather than complements in economic decision making, with an emphasis on the manufacturing sector alone as the driver for economic growth and development" (Siddiqui and Saleem, 2010, p. 167). Essentially, the thrust to improve competitiveness requires more services input in the operations. Owing to the intangible output of the services sector, they represent the "software" of the economy, which energises the industrial and agricultural sector, i.e. "hardware" of the economy (Siddiqui and Saleem, 2010).

In developed countries, logistics has already been recognised as an integral factor of competitive advantage (Bowersox and Closs, 1996) while some has considered it as a strategic industry (Gundlach et al; Sum et al, 2001). In Malaysia, the importance of the industry and potential for growth was only realised during the preparation of the Industrial Master Plan 3 (2006-2020) (Mohd Ali et al, 2008). Previously, it was viewed as a supportive industry to other functional areas rather than as a strategic industry on its own. The transformation of economy from agriculture-based to a trade-driven based as well as the development of international trade within the last decade has stimulated awareness that transport and logistics sector plays a critical role in facilitating the country's economy.

As a result, Malaysia Logistics Council (MLC) has been established to strengthen and promote the crucial logistics services in Malaysia. MLC provides leadership for the overall coordination of strategies, policies, regulations and rules associated with the development of the logistics industry (NST, 2006; Business Times, 2006). The setting up of MLC involves a strategic partnership with the private sector. This partnership provides a structured platform for both the private sector and government agencies to work together in addressing challenges facing the industry as the industry gears itself towards global competitiveness.

Despite the potential growth of the industry, the industry has been fragmented and uncoordinated due to the lack of focus given to the industry. The logistics activities have not been viewed as an integrated supply chain, but as segregated activities. Issues such as segregated logistics activities causing multiple handlings, poor coordination on the operation, limited market coverage, lack of real time information due to limited information technology capabilities, uncompetitive logistics service providers due to escalating in cost and inadequate volume keep brewing in the industry. In a study on the issues and challenges of the logistics industry in Malaysia, Mohd Ali et al (2008) viewed the list of issues from four different perspectives, namely (1) the policy related issues, which concerns with planning, implementation and control, (2) operational logistics, which concerns with the flow of goods, (3) service response logistics, which concerns with the flow of services, and (4) information logistics, which concerns with the flow of information.

RESEARCH METHODOLOGY

This on-going research assesses the issues and challenges faced by the logistics and supply chain industry in a developing country by taking Malaysia as an example. By analysing these issues and challenges, Malaysia could identify the industry's weaknesses, thus strategising and gearing itself towards achieving global competitiveness. In this study, two types of data were obtained. First, five (5) preliminary telephone interviews have been conducted. Each interview took less than an hour. The questions focused on the background of the informants, the industry they are in and the most critical problems they have encountered in their daily operations (refer to Table 1). The informants have been selected based on the researchers' industry network using the snowballing sampling technique. This is due to the fact that knowing the informant well is very important in Malaysian culture in obtaining a comprehensive picture, "true and real issues" of the industry. Second, information from a two-day International Conference in Logistics and Supply Chain Conference in Malaysia (ICLSCM, 2009) focusing on the issues and challenges of the industry was recorded. The Conference grouped the issues in the perspectives of institutions, logistics service providers, customers/users and education providers.

Position	***Industry***	***Type of company***	***Length of Experience in the industry***
Logistics officer	Electronic and semiconductor	Manufacturers	Less than 5 years
Director/owner	Agriculture	Logistics service provider-lorry operators	More than 20 years
Director/owner	Logistics	Forwarding agent	More than 10 years
Automotive components executive	Automotive	Manufacturer & Assembler	Less than 5 years
Director/owner	Construction	Contractor	10 years

Table 1: The Background of Informants

The analysis of issues and challenges from the literature review, interviews and the information from the Conference, therefore formed the basis of the conceptual framework and propositions developed for the study.

CONCEPTUAL FRAMEWORK AND PROPOSITIONS
Figure 1 visualises the proposed framework of global competitiveness of logistics industry in developing countries by taking Malaysia as an example.

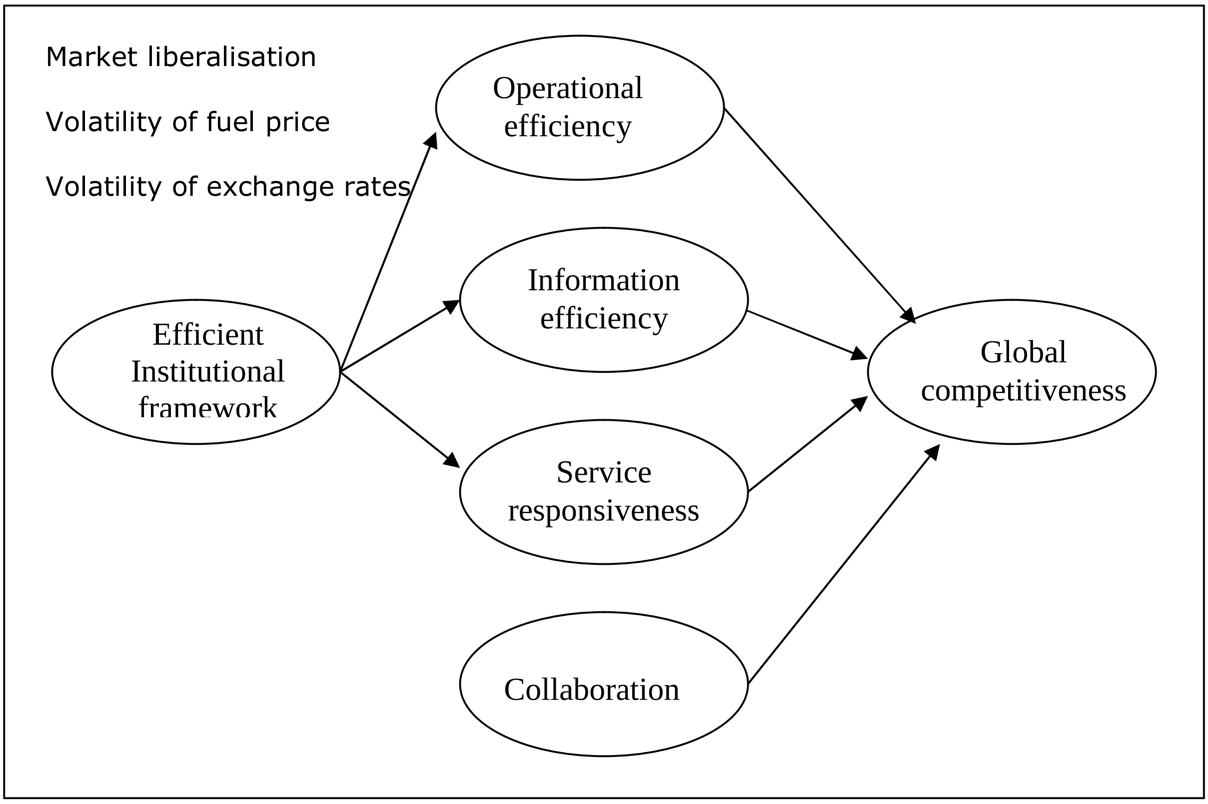

Figure 1: The Conceptual Framework of the Malaysian's Logistics Industry's Global Competitiveness

Global competitiveness
IMP3 runs from 2006 to 2020 with the aim to achieve long-term global competitiveness through transformation and innovation of the manufacturing and services sectors. Although Malaysia should feel proud on the fact that Malaysia was placed at 24th position out of 133 countries in the Global Competitive Index (GCI) 2009-2010 by the World Economic Forum; but the fact that it slipped downward by three positions from the previous year should not be taken for granted. Various strategies should be taken to rectify the situations. This study proposed several dimensions that need to be given attention towards driving global competitiveness of the logistics industry, which are discussed in the followings.

Public Policy
Efficient institutional framework was found to be the most important dimension that needs to be given attention. The institutional environment refers to the administrative framework within which individuals, firms and governments interact to generate income and wealth in the economy. The World Economic Forum (2009) identifies that the decline of Malaysia's GCI 2009-2010 was essentially the results of unfavourable assessment of institutional framework, which had been exhibiting a downward trend since 2007, causing Malaysia to fall from 17th to 43rd position in this dimension in just two years. Although various measures have been taken by government to facilitate

companies towards achieving global competitiveness of the country, but issues with regard to the lack of unified and standard forms of regulatory implementation resulting to various loopholes throughout the process are still being debated. The forwarding agent claimed that *"The frequent changes of procedures imposed by the authority always put the operators in trouble"* and *"Although there are many rules and regulations imposed by the Customs in clearing goods, however, these rules would not he able to stop any 'cheating and discrepancy' to occur…".* The lorry operator also highlighted that *"the conflicts among the authorities occurred during the enforcement of regulations resulting to the unethical method of problem solving and delay in the delivery"* (Mohd Ali, 2008).

Mattsson (2003) identifies that the dynamic influence of the political/institutional norms on globalisation is important. Those influences include public policy, trade regulations, competition laws and public investments in infrastructure. Fligsteinand Merand (2002), for example, discuss on the role of public policy for Europeanisation vs globalisation, while Morash and Lynch (2002) demonstrate the role of public policy for effective reorganisation of supply chains. Porter (1990) argues that there is a crucial link between the national environment and firm level of competitive advantage in that the national competitiveness strongly relies on both the economy and the specific industries. The government should play their role as "a catalyst and challenger, i.e. to encourage or even push companies to raise their aspirations and move to higher levels of competitive performance". This is important as in the globalised economy; companies will confront new and more risks, or a different combination of risks, including supply chain vulnerability, overcapacity, accelerated or more unpredictable price movements, and theft of intellectual capital ("piracy defense") (Slywotzky et al, 2006). Thus, effective risk management is equally vital. By establishing this efficient public policy, then only other dimensions could follow which finally achieving global competitiveness of the industry.

Operational efficiency and Service Responsiveness

Porter (1985), through his "Diamond Model" identifies operations, marketing and sales and service as three out of five primary activities in the value chain analysis that are vital in improving competitive advantage. Similarly, Bhatnagar and Teo (2009) also indicate that logistics operational and customers are the measures/indicators of competitiveness that lead to improved supply chain. In Malaysia, the problems of lack and skilled manpower have been the one of the constraints in achieving operational efficiency. The existing hauliers, for example do not have appropriate experiences and skills in introducing the new services and bringing innovative solutions to the higher-end clients (Thong, 2007). As indicated by the forwarding agent: *"The forwarding agent operators normally do not have basic training in logistics, but only from their experience. Therefore, they are not-proactive in providing solutions to the clients…"*

The rapid development of the industry and the lack of emphasis on service excellence have also consequently given rise to the need for more sophisticated management and responsive service from the logistics companies. Thus, it becomes a challenging task to gain those skills and knowledge in bringing the logistics industry upfront (Mohd Ali, 2008). Research in the areas has also not been given attention, thus affecting the development and best practice management in operational aspects and customer service. For example, one of the informants (Logistics officer) indicated that *"the lack of Key Performance Indicators in the semiconductor industry has caused a lot of problem in the manufacturing process as well as meeting customer satisfaction.* The R & D Centre could become the focal point for advanced research in the field of logistics, supply chain and transportation management. Thus, it is proposed that operational efficiency and service responsiveness should also be the source of competitive advantage.

Information Efficiency

As the supply chains become lengthy and complex, the efficiency of information becomes crucial as it requires greater communications capabilities, both within individual companies and between companies. "Information inaccuracy, information asynchrony, and missing information can disrupt supply chain operations, and result in lost sales revenues, over-stock or out-of-stock, long cycle times unreliable delivery of goods and services, and other problems" (Crandall et al, 2010, p.425). The prevalence of the bullwhip effect erratic changes in orders along the supply chain demonstrates the urgency of accurate and timely information flows along the supply chain.

In Malaysia, the government has made significant progress in achieving its vision integrating the industry players towards establishing a fully paperless custom clearance and trade facilitation through Electronic Data Interchange (EDI). However, problems still arise with regard to (1) costly EDI pricing and charges due to lack of transparency of profit margin charged by the freight forwarder, (2) overall performance and functionality of the system (Mohd Ali, 2008). Considering the primary importance of information efficiency, this study proposed that information efficiency may influence global competitiveness of the industry provided that support is given by the government institutions.

Collaboration

One of the main problems faced by the local service providers is the inability to participate/collaborate in international activities as a result of limited IT linkage, overseas corporate network and capital investment. Although International Freight Forwarder (IFF) exists in the market, however their existence is not helping the local service provider. This is because IFF is not transparent to the local service providers in terms of sharing their knowledge and development plans towards enhancing the industry (Mohd Ali et al, 2008). The limited range of logistics services would restrain the growth of small domestic market. As a result, they only confine to operate within the nation's borders (MIMA, 2008). As emphasised by the logistics officer, *"In the electronic and semiconductor industry, a lot of product defects occurred during the delivery process resulting from the weakness of the logistics service provider….and a lot of cases happened where the components did not reach on time as agreed in the initial contract".*

DISCUSSION

Taking together all the review from the literature and problems in the industry, plenty of work needs to be done for the logistics industry in developing countries, particularly Malaysia. Previous studies conducted in other countries could be guidelines in establishing strategies to restructure and reshape the Malaysian logistics industry. As suggested by Stock (1997), strong theoretical foundation in various contemporary research, developments and findings that are potentially relevant to the examination of various logistics issues in Malaysia context could be applied without having to reinvent the wheel. For example, the value chain model by Porter (1985) and models proposed by Siddiqui and Asghar (2008) and Siddiqui and Saleem (2010) could perhaps provide a better understanding on the structure of the logistics industry problems. Bhatnagar and Teo (2009), for example suggest that inventory, transportation, information and facilities are four drivers of supply chain competitiveness. This study, however, suggests that collaboration should be considered as equally important. With the globalisation of market, the issue of gaining trust and ability to collaborate with the business partners in a diverse culture becomes an important factor to be successful in business as these could be the soft measures of an effective supply chain performance. Thus, two parallel strategies from the perspectives of operational (flow of goods/materials, services and the flow of information) and relational (ability to collaborate) should be strengthened and implemented by the responsible parties in achieving global competitiveness. This is important because with the liberalisation of market that is taking place very soon, the understanding on the changes in the logistics structure and landscape is becoming more complex.

Secondly, the data in this study revealed the crucial role of the policy makers in providing support and determine the directions of the industry as it may give direct impacts to service and operational efficiency offered by the industry players (Mohd Ali et al, 2008). In doing this, the players and the government institutions should differentiate the external and internal issues due to the difference in the ability to control the issues. Effort and strategies should be focused on improving the internal issues as they are within the control of the industry. Concurrently, different synergies should be placed at reducing the effect of the external issues. For example, in a recent conference on logistics and supply chain in Malaysia, intense competition as an effect from liberalisation of trade and services, overcapacity resulted from the economy recession and the volatility of the fuel price were identified as three categories of external issues (ICLSCM, 2009).

Third, the approach to tackle the issues in the industry should be viewed from a holistic approach across industrial sectors rather than in isolation. For example, the application of information technology to the whole industry could be a solution to various management and efficiency issues.

Finally, research and learning collaborations among the government-industry-university should be strongly encouraged in dealing with these human resource, operational and policy issues (Mohamad and Jaafar, 2009). Collaboration in training could enhance the skills and knowledge of the existing practitioners while collaborations in research and development could help the industry in introducing and improving various techniques and technologies in the operational as well as bringing best practice forward.

CONCLUSION

The overview of the current development, changes and issues in the logistics and supply chain sector in Malaysia provides several insights to the present situation of the country. Other developing countries may face similar challenges although the detail of the problems might differ. Therefore, this paper attempts to propose a framework that could become a guideline for improving the logistics and supply chain industry in developing countries, particularly Malaysia as it opens up numerous areas for research and improvement as well as identifying its priorities. Consequently, it poses numerous challenges to all levels of relevant parties ranging from the top management i.e. policy makers and government agencies down to small logistics-related companies.

REFERENCES

Anderson, J. (2009) Expanding globally with local vision: Foreign market entry and the value chain, Journal of Business Strategy, Vol. 30 No.5, pg 32-39.

Bhatnagar, R. and Teo, C.C. (2009) Role of logistics in enhancing competitive advantage – A value chain framework for global supply chains, International Journal of Physical Distribution and Logistics Management, Vol. 39. No.3, pp.202-226.

Bowersox, D.J. and Closs, D.J. (1996), Logistical Management – The Integrated Supply Chain Process, McGraw Hill, New York, NY.

Business Times (2009), Box Traffoc at Malaysia Ports up 10% in Q2, 31st July.

Fligstein, N. and Merand, F. (2002), "Globalisation or Euroepanisation? Evidence on the European Economy since 1980", Acta Sociologica, Vol.45, pp.7-22.

Gundlach, G.T.; Bolumole, Y.A.; Eltantawy, R.A. and Frankel, R. (2006) "The Changing Landscape of Supply Chain Management", Marketing Channels of Distribution, Logistics and Purchasing, Journal of Business and Industrial Marketing, Vol.21 No.7, pp.428-438.

International Conference in Logistics and Supply Chain In Malaysia (ICLSCM) (2009) "Issues and Challenges", Malaysia Institute of Transport (MITRANS), Shah Alam, 4-5 August.

International Monetary Fund (1997) World Economic Outlook, May.

Maritime Institute of Malaysia (2004), Key Issues in the Malaysian Freight Logistics Industry, available online at: http://www.mima.gov.my/mima/htmls/papers/pdf/esoi/freight-logistics.pdf (accessed on 31st July 2008).

Mattsson, L. G. (2003) "Reorganisation of distribution in globalisation of markets: the dynamic context of supply chain management", Supply Chain Management: An International Journal, Vol.8 No.5, pp.416-426.

Mohamad, S. and Jaafar, H.S. (2009), University-Industry Collaboration: The Role of a Research Centre of Excellence in Malaysia, Proceeding of the Eastern Asia Society for Transportation Studies, Vol.7, Surabaya, Indonesia.

Mohd Ali, R.; Jaafar, H.S. and Mohamad, S. (2008) "Logistics and Supply Chain in Malaysia: Issues and Challenges, EASTS International Symposium on Sustainable Transportation incorporating Malaysian Universities Transport Research Forum Conference 2008 (MUTRFC), Universiti Teknologi Malaysia, 12-13 August.

Morash, E.A. and Lynch, D.F. (2002), "Public policy and global supply chain capabilities and performance", Journal of International Marketing, Vol.10 No.1, pp.25-51.

Porter, M.E. (1990), The Competitive Advantage of Nations, The Free Press, New York, NY.

Rushton, A. And Walker, S. (2007) International Logistics and Supply Chain Outsourcing: From Local to Global, Kogan Page, London.

Siddiqui, S.H. and Saleem, H.M.N. (2010), "Services-lead industrial policy for inclusive growth and competitiveness", Competitiveness Review: An International Business Journal, Vol.20 No.2, pp. 166-181.

Siddiqui, S.H.. and Asghar, W. (2008), "Linking training with productivity and competitive strategy: implications of value chain model for strategically effective training programs", International Review of Business Research Papers, Vol.4 No.1, p.2008.

Slywotzky, A., Baumgartner, P., Alberts, L. And Moukanas, H. (2006) Are you enjoying globalisation yet? The surprising implications for business, Journal of Business Strategy, Vol.27 No.4, pp. 23-32.

Sum, C.C. and Teo, C.B. (2001), "Strategic Logistics Management in Singapore", International Journal of Operations and Production Management, Vol. 21 No.9, pp. 1239-1260.

Schwab, K. (2009), "The Global Competitiveness Report 2009-2010", World Economic Forum, Geneva.

Thong, Y.C. (2007), "Overview – the Logistics Industry in the Northern Region & the Need to Enhance its Effectiveness and Competitiveness, Penang Logistics Seminar, July 5.

Williamson, P.J. (2005) Strategies for Asia's new competitive game, Journal of Business Strategy, Vol.26 no.2, pp.37-43.

CHARACTERISING THE LOGISTICS SECTOR: WHAT AND WHERE IS THE LOGISTICS-RELATED EMPLOYMENT IN AUSTRALIA?

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ABSTRACT

Purpose: The definition, identification and characterisation of logistics as an industry sector are contentious. In this paper, we set out three research questions: 'what industries represent the logistics sector?' 'What 'logistics functions' does it perform'; and 'what localities do these functions serve?'

Methodology/Design: Using the 4-digit ANZSIC classification employed by ABS (Australian Bureau of Statistics), industries that are explicitly related to logistics are first identified and then aggregated at a small area level. These industries are then compressed into broader functions to characterise the logistics sector using multivariate analysis.

Research Findings: Results show that the total employment at a national level in the logistics sector is 3.57 percent of total employment. Road freight, postal services and air and space transport are identified the major employers of logisticians. Using a factor analysis, four 'logistics functions' were extracted to define the underlying structure of the logistics sector. These functions include: 'road-centred', 'port-centred', 'airport-centred' and 'rail-centred' logistics functions.

Research Limitations: The labour force working as logisticians or supply chain managers in other industries such as manufacturing could not be captured through this data and thus could not be reported in this paper.

Practical Implications: A high degree of functional coherence across factors was observed. This suggests the existence of clustering *vis-à-vis* integration of industries that are inter-related and interdependent. To manage more effectively the distribution of logistics activities, an approach based on the development of regionally integrated logistics systems is advocated so that the diversity, vibrancy and interdependency of the identified logistics clusters can be sustained.

Originality/value of the paper: The attempt to define and characterise the logistics sector at a small area level using the lowest level of industrial classification is the original contribution of this paper.

INTRODUCTION

Logistics has long been a fundamental enabler of trade. Throughout history the great trade routes such as the Silk Road and the ancient spice routes have enabled international trade of commodities, bringing wealth and prosperity to nations. International trade today remains key to regional economic development (Song et al., 2009). Regions that successfully forge international trade links are likely to witness a significant increase in competitiveness and rapid economic development (Arvis et al., 2007). Grossman et al. (2007) show that growth in global gross domestic product (GDP) has a close association with international trade growth. Despite the importance of the logistics sector, there is very little known about the size, characteristics and distribution of logistics related employment in Australia at a smaller area level.

The aim of this paper is three-fold. Firstly to identify different economic activities that characterise the logistics sector, secondly to delineate the broader 'logistics functions' that represent the underlying structural characteristics of logistics employment, and thirdly to map locales where these logistics functions are concentrated. In so doing, we can establish the share of this logistics sector to the total employment at a small area level that then enable the identification of spatial clusters through which future investment on infrastructure can be mobilised and the workforce can be training to meet the demand in areas of growth.

LITERATURE REVIEW

At the beginning of the 21st century, logistics has become a key facilitator of national economic development, in line with growth in international trade. From 1950 until 2000, global trade volume increased by 6% annually, and continues today (Grossman, et al., 2007). The Logistics Performance Index (LPI) developed by Arvis, et al. (2007) defines the importance of logistics to a national economy. As a resource rich nation, and developed economy Australia is a major player in international trade. Exports range vastly from commodities such as minerals and food products to added value products such as automotive and pharmaceuticals. Meanwhile, Australia is also dependent on various imports. With a current LPI score of 3.79, it is ranked the 17th most logistics-active country (Arvis, et al., 2007). Hence this island nation located far from other major markets and producers is dependent on international trade. Yet Mollenkopf and Dapiran (2005) find that Australian logistics firms are more internally integrated than externally. That is to say that whilst they offer individual World-class capabilities, their logistics operations are less proficient than the study's US benchmark. The authors attribute this to recent adoption of best practices, caused by only recent diversification to a wider range of international trade partners over the past few decades, coupled with relative distance from those partners. Australian firms are still in transition from a commodities trade focus to an added-value products focus (Mollenkopf & Dapiran, 2005).

Robinson (2006) reports that the recent growth of logistics activities from Australia's major ports of Melbourne and Sydney is placing increased demands on infrastructure such as the road networks, and is offering opportunities for added-value logistics. As such Robinson (2006) finds that a strategic focus on enhancing what is termed port-oriented landside logistics is necessary to improve the flow of logistics through the ports and cope with continued growth. Mangan, et al. (2008) extend this argument to propose that ports themselves offer a more strategic role than has been conventionally perceived. Moving to inland Australia, the formation of a National Road Transport Commission and a National Rail Freight Corporation in 1991 aimed to address the logistics industry growth discussed above (Laird, 1992). As such, the Australian logistics industry is a major employer.

In this research we identify the location of logistics functions in Australia to identify constraints and opportunities in infrastructure planning to maintain or enhance the nation's LPI ranking. Geography matters. The emergence of logistics cities and regions around the world is the evidence of the role that logistics plays in the post-Fordist economy. Logistics activities tend to cluster around areas of comparative advantage and form logistics hubs. These hubs are functional nodes of high economic activity, creating regional growth and forming foci of innovation (Chhetri et al., 2008; Song, et al, 2009). They are empowered to control and regulate the distribution of freight and thus they act as gateways to and from a region/country, shaping the way commodity logistics operations are formed. In some regions, economic activities concentrated at transport terminals such as ports or airports create logistics cities where a large spatial accumulation of logistics related value-adding activities. Hence these logistics cities contribute significantly to a regional and national economy as well as to help achieving the economies of agglomeration by encouraging co-location of firms in areas around those clusters.

METHODOLOGY

Two primary data sources were used in this study: 2006 Census Journey to Work (JTW) data (using the Australian New Zealand Industrial Classification (ANZSIC)) and GIS coverage for destination zones (in this case Statistical Local Areas (SLA). The JTW data provided information about where people live and work, what industry they work in and what transport modes they use. The types of industry in the JTW data were classified using the ANZSIC codes at a four-digit level, supplied by the Australian Bureau of Statistics for the 2006 census, where JTW data comprises the number of jobs by industry types. Destination data were used to capture logistics-related employment. Data were imported into the GIS, and combined with the JTW data using the SLA codes as a primary key. A factor analysis has been conducted on the logistics related industries and the results produced in the form of factors are then mapped in GIS.

RESEARCH FINDINGS

Statistical analysis was conducted in three stages. Stage 1 identified logistics related employment at a small area level using four-digit data. Stage 2 compressed these industries into components called "logistics functions" to define the underlying structural dimension of the logistics sector. These logistics functions were then mapped out in stage 3 and their spatial patterns represented in the form of maps. These three sequential stages are discussed below. First we define our terminology. We use the term 'logistics sector' to differentiate logistics from other business sectors such as manufacturing and retail. 'Logistics functions' defines those logistics activities that are either road, rail, airport or port-related.

Stage 1: Identification of the logistics related jobs

The first stage of analysis was to identify the industries that are associated with logistics. Industries that are marginally related to the logistics sector were not considered in our research. For example, people employed in the manufacturing sector as logisticians or supply chain analysts could not be differentiated through this dataset. The component of passenger logistics except air transportation was also excluded. Our research focused on freight logistics. The sector was strictly confined to those industries that provide logistics functions.

Industries	**Number of logistics Jobs**	**% of total jobs**	**%age of total logistics jobs**
Road Transport	523	0.006	0.16
Road Freight Transport	162449	1.784	49.93
Rail Transport	4001	0.044	1.23
Rail Freight Transport	8306	0.091	2.55
Water Freight Transport	2649	0.029	0.81
Air and Space Transport	38433	0.422	11.81
Pipeline Transport	452	0.005	0.14
Other Transport	572	0.006	0.18
Postal and Courier Pick-up and Delivery Services	215	0.002	0.07
Postal Services	42528	0.467	13.07
Courier Pick-up and Delivery Services	14419	0.158	4.43
Water Transport Support Services	109	0.001	0.03
Stevedoring Services	5185	0.057	1.59
Port and Water Transport Terminal Operations	4510	0.050	1.39
Other Water TSS	3100	0.034	0.95
Airport Operations	6302	0.069	1.94
Customs Agency Services	2183	0.024	0.67
Freight Forwarding	14247	0.156	4.38
Other TSS	12893	0.142	3.96
Grain Storage Services	2288	0.025	0.70
Warehouse & Storage Services	17174	0.189	5.28

Logistics Employment	**325364**	**3.574**	**100.00**
Total Employment	**9104187**		

Table 1: Industrial composition of the logistics sector in Australia

JTW data at a four-digit level comprise a total of 717 industries. These industries were individually evaluated for their association with the logistics sector. The total counts of employment across these industries within the logistics sector are given in Table 1.

Once the industries that related to logistics were identified, the next step was to aggregate them to form the logistics sector. The total number of employees in the logistics sector was 325,364 in Australia in 2006, which accounts for the 3.57% of total employment.

State-wide analysis provides a summary of the spatial distribution of logistics-related employment. Table 2 shows that there is a relatively higher level of logistics activities concentrated in New South Wales, Victoria and Queensland. However, when comparing logistics employment with total employment, there is some symmetry in the distribution except for Northern Territory and ACT.

States	Logistics Job	Total Jobs	%age of total Logistics Jobs	%age of total Jobs
New South Wales	106872	2720918	33.36	3.93
Victoria	80837	2141279	25.23	3.78
Queensland	66679	1711507	20.81	3.90
South Australia	22212	652733	6.93	3.40
Western Australia	30961	880472	9.66	3.52
Northern Territory	2910	192989	0.91	1.51
Tasmania	6767	192989	2.11	3.51
ACT	3096	184087	0.97	1.68
Other Territories	45	1273	0.01	3.53
	320379	**8678247**	**100**	

Table 2: State-wide distribution of logistics employment

Stage 2: Quantifying the logistics functions within the logistics sector

In order to quantify the logistics functions, we applied principal component analysis (PCA) to the 28 logistics-related functions. The purpose was to identify groupings based on structural commonalities in the data. The industries where the number of jobs is less than 200 were not subjected to PCA. These were either merged or eliminated from the dataset. In addition, warehousing and storage services and other warehousing and storage services were amalgamated. For this dataset, the calculated Kaiser-Meyer-Olkin (KMO) of 0.802 exceeds the 0.5 level considered to be acceptable for the use of PCA. Items were retained if their loadings on one of the factors was greater than 0.40. Items that failed to fulfil this criterion were removed.

Using a varimax rotation technique, four components with eigenvalues greater than 1 were extracted. These components were also tested for internal reliability using Cronbach's alpha. The first component accounts for the greatest proportion of variance (19%) and the five items defining it have high loadings from 0.59 to 0.89. The second component explains around 17.6% of the variance and the six items defining it have loadings from 0.45 to 0.82. The third component is defined by four items with loadings from 0.66 to 0.88. The final component has high loadings on four items with loadings that range from 0.54 to 0.69. These components are descriptively labelled and together explain 62% of the variability in observations.

The industries across these broader functions were then aggregated. The 'road-centred' logistics function employs the largest number of workers and 59% of the total logistics sector. The second largest employer is the 'airport-centred' function that accounts for 19% of the logistics workforce. This is closely followed by the 'rail-centred' logistics function, which is 17% of total logistic employment. Finally, the 'port-centred' logistics function is the smallest sub-sector that provides employment to around 15,553 people.

'Road-centred' logistics functions tend to be orientated around road transportation or the value-adding services such as warehousing and storage provisions. This logistics function is largely defined by trucking industries, providing a total of 194,780 jobs. 'Airport-centred' logistics functions support air transportation. It is the second largest logistics function and serves the industry with 61,156 employees, which is about 19% of total logistics jobs. 'Rail-centric logistics functions' are largely clustered around rail network and terminals. Postal services that are often delivered through rail transportation are also correlated with rail transport. Courier and pick delivery services, often privately owned, are correlated with road transport, which facilitates door-to-door services. The function employs 19% of total logistics jobs and comprises around 55,000 logistics workers. 'Port-centred' logistics functions congregate around port and are dependent on port activities. These industries create large industrial or business complexes around ports. It is the smallest sub-sector with a total employment of around 17,841 (5 percent).

	Component			
	Road-centred logistics functions	**Port-centred logistics functions**	**Airport-centred logistics functions**	**Rail-centred logistics functions**
Road Freight Transport	**.897**	.192	.182	.159
Road Transport	**.837**	.107	-.037	.074
Courier Pick-up and Delivery Services	**.756**	.177	.405	.158
Warehouse	**.626**	.088	.221	.135
Postal and Courier Pick-up and Delivery Services	**.597**	.214	.141	.096
Other Water TSS	.100	**.825**	.059	.067
Port and Water Transport Terminal Operations	.000	**.803**	.037	.193
Stevedoring Services	.083	**.683**	.286	-.073
Water Transport Support Services	.297	**.633**	.030	.186
Water Freight Transport	.374	**.584**	.276	.032
Grain Storage Services	.159	**.457**	-.082	.102
Customs Agency Services	.153	.191	**.885**	.094
Air and Space Transport	.083	.037	**.884**	.069
Freight Forwarding	.308	.120	**.843**	.142
Airport Operations	.115	-.016	**.668**	.009
Rail Freight Transport	.039	.397	.001	**.697**
Pipeline Transport	.117	-.068	.130	**.646**
Rail Transport	.399	.483	.014	**.570**
Postal Services	.441	.186	.141	**.548**

	Component			
	Road-centred logistics functions	**Port-centred logistics functions**	**Airport-centred logistics functions**	**Rail-centred logistics functions**
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Pipeline Transport	.117	-.068	.130	**.646**
Rail Transport	.399	.483	.014	**.570**
Postal Services	.441	.186	.141	**.548**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 3: Rotated logistics functions

Stage 3: Mapping the logistics functions for Victoria
In order to generate the Victorian logistics landscapes, the logistics-related industries are aggregated to form the logistics sector and then mapped. It is important to map these landscapes so that the degree of spatial clustering around areas of strategic importance can be identified and the associated infrastructure to support the activities can be spatially correlated. Appendix 1 maps employment in the Victorian logistics sector to illustrate one city-based cluster and three distinct logistics clusters around Melbourne. Porter (2000) defines a 'cluster' as a group of interrelated companies and associated institutions that cooperate and compete to generate wealth located within a geographic area. Cluster theory establishes that competitive advantage may arise from agglomeration economies – co-location of buyers, sellers and relevant others that minimise operating cost structures, encourage sharing technology, and develop business networks (Porter 2000).

These logistics clusters exhibit a high degree of economic vibrancy and therefore require infrastructure to support the movement in or out of these hubs. These logistics clusters are of high economic significance and should be connected through better road and rail networks so that various commodity logistics operations can be streamlined. Spatial clusters that support significant strategic nodes such as ports and airports needs to be connected through intermodal facilities. In addition, urban and land use planning considerations around these logistics clusters should also help mitigate the potential disruptions in the commodity logistics operations.

CONCLUSIONS

Logistics as a well-defined industrial sector is debatable. It is equally difficult to measure the size of the sector due to the overlap with other sectors such as manufacturing. This paper identified the industries that are directly related to logistics. Logistics-related jobs in other sectors such as manufacturing largely remain unknown.

Represented through the classifications listed in table 1, the logistics sector employs around 3.57 percent of total employment in Australia; however there is a large variability across cities and regions. Road freight, postal services and air and space transport are identified the major employers of logisticians. Using factor analysis, four 'logistics functions' were extracted to define the underlying structure of the logistics sector. These functions include: 'road-centred', 'port-centred', 'airport-centred' and 'rail-centred' logistics functions. These explicitly represent the amount of modal and intermodal supply in the logistics sector. The results show a high degree of functional coherence among the identified logistics functions. This might be an indication of greater inter-dependence and integration of interrelated and interconnected industries through shared resources and knowledge. It might also mean a reduction in transaction costs, greater access to common labour pools and in general greater economies of scale.

Distinct spatial clusters were also being identified. This would be indication of the spatial accumulation of logistics related activities around certain well defined nodes. Through co-location in and around these clusters, we envisage that firms are benefited when they locate near each other through the economies of agglomeration and spatial division of labour. Firms would also have greater opportunities to be able to innovate by sharing accumulated information that flow through the network within the cluster.

The mapping of logistics spatial clusters provides myriad opportunities to geo-target areas where a high or low demand for logistics skills is reflected. Logistics councils and other stakeholders in Australia could potentially use these maps to strategically plan area-specific training and apprenticeship programs to constructively align to areas where they are needed.

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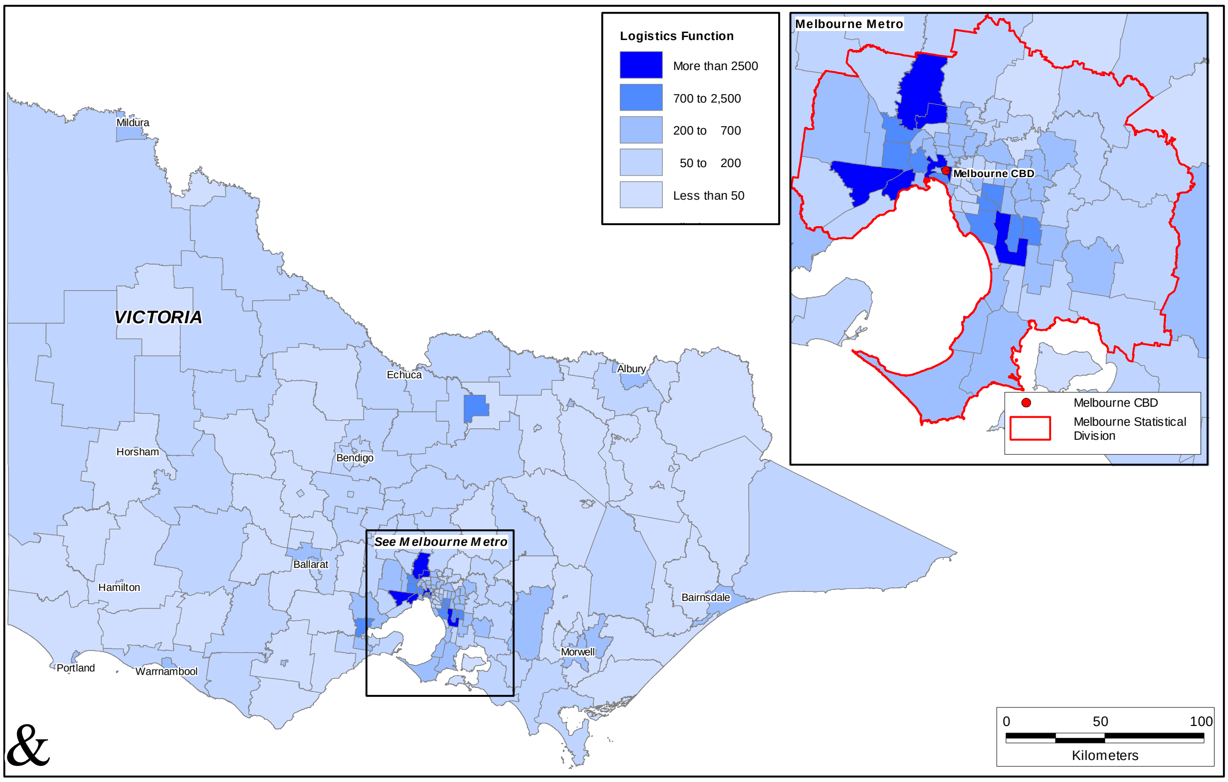
REFERENCES

- 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.
- Mangan, J., Lalwani, C. and Fynes, B. (2008) Port-centric logistics, *International Journal of Logistics Management*, 19(1), pp29-41.

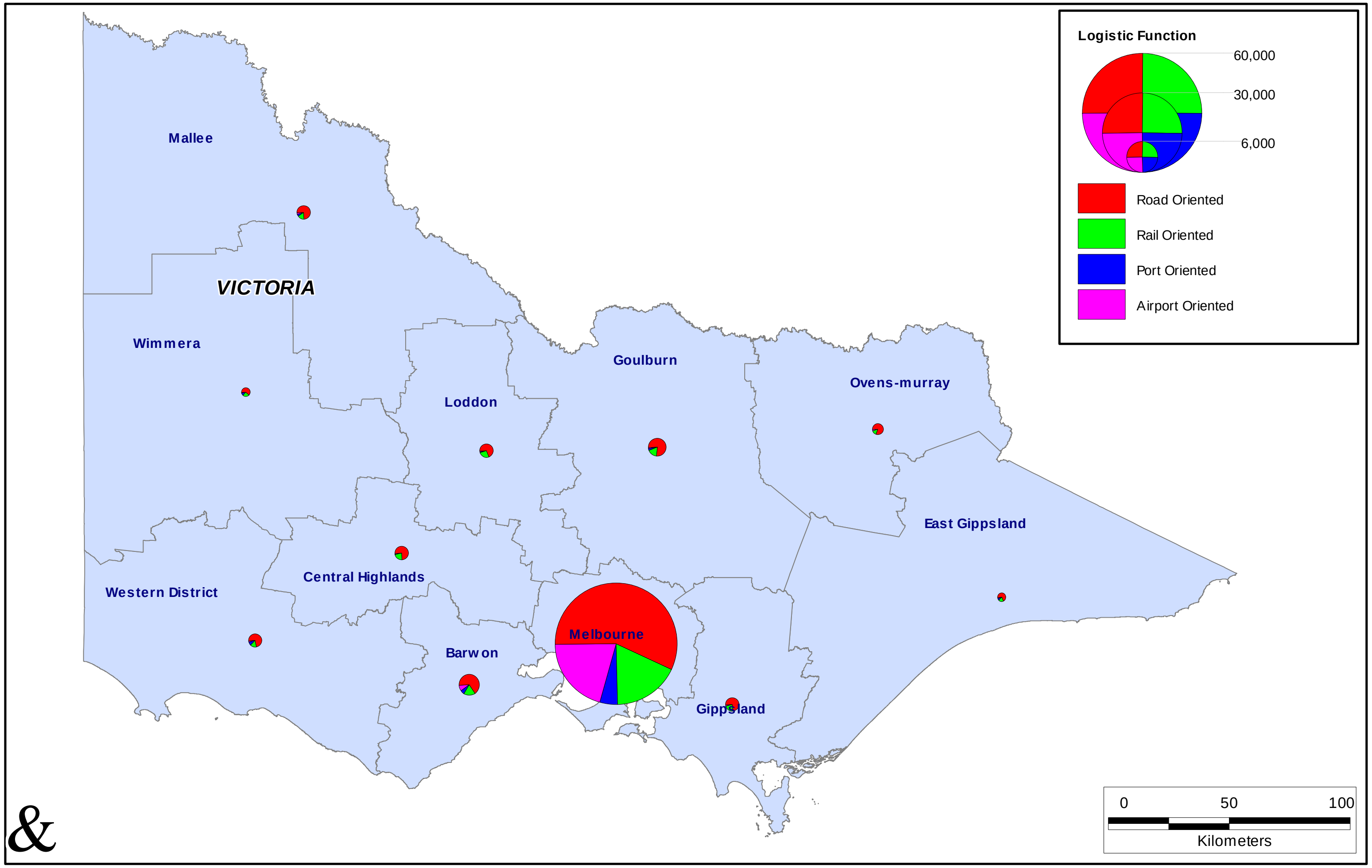
- Mollenkopf, D. and Dapiran, P. (2005) World-class logistics: Australia and New Zealand, *International Journal of Physical Distribution and Logistics Management*, 35(1), pp63-74.
- Porter, M.E. (2000), Location, competition and economic development: Local clusters in the global economy, *Economic Development Quarterly*, Vol.14-1: 15-31.
- Robinson, R. (2006) Port-oriented landside logistics in Austalian ports: a strategic focus, *Maritime Economics and Logistics*, 8, pp40-59.
- Song, J., Butcher, T. and Mangan, J. (2009) Regional logistics capability and economic development in the Yorkshire and Humber region, *Proceedings of the Logistics Research Network Annual Conference*, Cardiff UK, 9-11 September 2009.

APPENDIX 1: EMPLOYMENT IN THE LOGISTICS SECTOR



Logistics Function - Victoria

APPENDIX 2: EMPLOYMENT IN EACH LOGISTICS FUNCTION



Logistics Function - Victoria

VECTOR AUTOREGRESSIVE MODEL FOR THE FORECAST OF PORT CONTAINER THROUGHPUTS IN EAST ASIA

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ABSTRACT
Vector autoregressive (VAR) model is an econometric model proved to be a dependable approach to evaluate relationships among time series data. Accordingly, this study applies the VAR approach to develop prediction models of container throughputs for the major ports in East Asia. Our VAR models include the lagged values of container throughputs and gross domestic product for each port. The forecasting accuracy of each container port was compared by mean absolute deviation, mean square deviation, and mean absolute deviation. To avoid potential inference bias caused by the financial meltdown in 2008 and 2009, quarterly gross domestic product of Singapore, China, Hong Kong, and Korea and quarterly container throughput of port Singapore, Shanghai, Hong Kong, Shenzhen, and Busan were collected from year 1995 to 2006. Our findings indicate that GDP is a leading indicator of container throughput for the ports of Singapore, Hong Kong, and Busan. Meanwhile, the container throughput of Singapore, Shanghai, and Shenzhen is significantly affected by its lag data. From the perspective of goodness of fit, our VAR models generally provide acceptable results. As the MAPE values for all VAR models are less than 4%, it implies the reliability of VAR approach for the forecast of container throughputs. Comparing to other approaches like regression models or grey models, this study provides an alternative method with dependable predictions but requires less model assumptions. Port authority can easily apply our proposed approach to allocate sufficient port facilities for the upcoming demands.

INTRODUCTION
The ports of Singapore, Shanghai, Hong Kong, Shenzhen, and Busan in East Asia have been listed as the top five container ports in the world since 2003. Meanwhile, the total container throughput of these ports reaches 99 million TEUs in 2007, which is a 97.93% growth than in 2000. As these statistics show the increasingly important role of East Asia container ports in world trade, it's crucial for the port authority and government to expand their port capacity with enhanced technology in order to keep pace with the rapidly growing demand. Accordingly, how to provide reliable forecast models of container throughputs for port development has been a critical research issue. For example, Seabrooke et al. (2003) predicted the cargo growth in Hong Kong through the ordinary least square approach of regression analysis. Lam et al. (2004) applied neural network model to forecast the container throughput of Hong Kong. Guo et al. (2005) proposed a modified grey Verhulst model for one of the China's container port. Chou et al. (2008) developed a modified regression model for forecasting the container volume in Taiwan. Chen and Chen (2010) employed genetic programming to develop a forecast model for Taiwan's ports and compared their findings with the seasonal auto regression integrated moving average. Because these studies generally develop models only for a specific harbour or a country, this study would like to explore suitable forecast approach which is applicable for regional analysis.

The methodology we decided to adopt in this study is the vector autoregressive (VAR) model, which is an econometric approach proved to be dependable for the evaluation of mutual relationships among time series data (Lütkepohl, 2005). The application of VAR model can be found in many researches. For instance, Veenstra and Haralambides (2001) applied VAR model in vector error-correction form for forecasting long run seaborne trade flows of crude oil, iron ore, grain and coal markets and the results displayed relatively small forecast errors while predicting long-term seaborne trade flow estimation by the models. Guzhva and Pagiavlas (2004) employed VAR with revenue passenger mile and real gross domestic product series to estimate the effect of the September 11th terrorist attack on the performance of the US airlines from the general economic environment. Another example is in the study of Marcucci and Quangliariello (2008), they applied VAR to evaluate the degree to which macroeconomic shocks affect the banking sector and separate the feedback effects from the financial system to the real economy in Italian bank. As there is lack of research addressing the issue of container throughput forecast from the perspective of VAR approach, this study would like to investigate this issue through the analysis of the top 5 container ports in East Asia. Findings of this study enable us not only to evaluate applicability of VAR model in container throughput forecast but also to understand the relationships of container throughput series with its own lags and the lags of other variables in the model. The remaining of this paper is organized as follows. Section 2 presents the source of our data and the processes of VAR analysis. In the third section, the VAR forecast results of the top 5 ports are shown. Finally, conclusions are given in section 4.

METHODOLOGY

The VAR is a flexible and easy to use model for forecasting as it can be made conditional on the potential future paths of specified variables in the model. The explanatory variable used in this study is the gross domestic product (GDP), which is a common indicator for econometric analysis. For instance, Seabrooke et al. (2003) pointed out that a reliable forecast relies on the accurate assumptions of economic growth and GDP is the most importantly economic indicator. They predicted Hong Kong-China freight movement by GDP to establish OLS regression analysis. Lam et al. (2004) used one or two explanatory factors to explain their forecasting model for Hong Kong port cargo throughput. They stated that the growth of the port activities is related to the economic growth in Hong Kong. Therefore, GDP is adopted as one of explanatory factors, according to different types of freight movements. Chou et al. (2008) included the macro-economic variables such as GDP, agricultural GDP, industrial GDP, and service GDP to develop a modified regression model for forecasting the import container volume in Taiwan.

Accordingly, quarterly data of GDP in Singapore, China, Hong Kong, and Korea and quarterly data of container throughput in Singapore, Shanghai, Hong Kong, Shenzhen, and Busan were collected from AREMOS Statistical Data Bank and the official web site of each country for the longitudinal analysis. To avoid potential inference bias caused by the financial meltdown in 2008 and 2009, the data collection covers the period of 1995:Q1 to 2006:Q3. The data before 2005 was applied for model construction, while the rest of data was used for the analysis of forecast accuracy. The first process of VAR analysis in this study is to check the stationarity of the five throughput series data. Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) is used to test the existent of unit root. The test models with drift term, with time trend, and with neither intercept nor trend term were considered for our examination. The minimization of Akaike information criterion (AIC) (Akaike, 1973) was employed to determine the lag number of p. If the null hypothesis of unit root test is rejected, there is no unit root and therefore the series is stationary. For those nonstationary series, their first differences have to be applied d times to make the process stationary and we denote these processes I(d). If the throughput variable and its corresponding GDP variable have the same order of d, we followed the works of Johansen (1988, 1994) to investigate the existence of cointegration equations. In this study, the VAR models proposed by Johansen and Juselius (1990) are utilized for cointegration tests. If there was no cointegration relationship between the throughput data of container port and the corresponding GDP, VAR model can be used for throughput forecast. Our VAR models include the lagged values of container throughputs (in TEU) and gross domestic product for each port. A basic form of VAR model with two regressions can be expressed by

$$y_{t,j} = a_{0,j} + \sum_{k=1}^{p} a_{k,j} y_{t-k,j} + \sum_{k=1}^{p} b_{k,j} x_{t-k,j} + \varepsilon_{t,j}$$
$$x_{t,j} = a'_{0,j} + \sum_{k=1}^{p} a'_{k,j} y_{t-k,j} + \sum_{k=1}^{p} b'_{k,j} x_{t-k,j} + \varepsilon'_{t,j} \quad (1)$$

where $y_{t,j}$ denotes the container throughputs of port j at time t, $x_{t,j}$ denotes the country's GDP corresponding to port j at time t, and $j \in G$ in which G is the index set of container ports. Let

$$Y_{t,j} = \begin{bmatrix} y_{t,j} \\ x_{t,j} \end{bmatrix}, \quad A_{0,j} = \begin{bmatrix} a_{0,j} \\ a'_{0,j} \end{bmatrix}, \quad A_{k,j} = \begin{bmatrix} a_{k,j} & b_{k,j} \\ a'_{k,j} & b'_{k,j} \end{bmatrix}, \quad \varepsilon_{t,j} = \begin{bmatrix} \varepsilon_{t,j} \\ \varepsilon'_{t,j} \end{bmatrix}.$$

Then Eq. (1) can be simplified as the VAR(p) model

$$Y_{t,j} = A_{0,j} + A_{1,j} Y_{t-1,j} + A_{2,j} Y_{t-2,j} + \ldots.. + A_{p,j} Y_{t-p,j} + \varepsilon_{t,j} \quad (2)$$

where p denotes the lag interval of the model. The Likelihood ratio (LR) test was used to determine the optimal lag length. Meanwhile, the regression residuals were examined by Q-test and Jarque-Bera test to check whether the residuals are not autocorrelated and normally distributed respectively. The estimates of $A_{k,j}$ were evaluated by the maximum likelihood approach and the LR critical values for Johansen's models are extracted from the study of Osterwald-Lenum (1992). After the construction of VAR model for each port, we compared the forecasts of VAR models with the actual throughput data after year 2005 through the measurements of mean absolute deviation (MAPE), mean square deviation (MSD), and mean absolute deviation (MAD).

FINDINGS OF VAR FORECAST

The results of unit root test for the container throughput data and the corresponding GDP data show that all the variables are non-stationary. Thus, the first differences have to be conducted one or two times to make their processes stationary. According to our analysis, the throughput data of Hong Kong and Busan are found to be the I(1) processes while the throughput data of Singapore, Shanghai, and Shenzhen are I(2) processes. Regarding the GDP, only the Singapore GDP is I(2), whereas the GDP of China, Hong Kong, and Korea are I(1) series. Because the throughputs of Hong Kong, Busan, and Singapore have the same order with its country's GDP, these ports were further analyzed by Johansen's approach to understand the existence of cointegration relationships. Because our findings indicate that there are no cointegration relationships between the container throughputs and the corresponding GDP, these top 5 container ports are suitable to apply the VAR model for their throughput forecasting.

First of all, we developed the VAR model of container throughput for the port of Singapore. According to the results of LR test, the optimal lag length is 2 and therefore the results of two-lag VAR model are summarized in Table 1, where the coefficients were estimated by the maximum likelihood approach. Because the coefficients of throughput and GDP achieved at least 5% confidence level, the container throughput of Singapore can be predicted from the latest 2 quarters' throughput and GDP. Meanwhile, goodness of fit is acceptable as the R^2 is 59.25% and R^2_{adj} is 54.96%.

Independent variable	Coefficient	Standard error	t-value	p-value
Intercept	3428.53	-27101.20	0.13	0.90

THROUGHPUT (-1)	-0.34	-0.14	-2.48	0.02
THROUGHPUT (-2)	-0.37	-0.12	-3.04	0.00
GDP (-1)	-61.17	-13.78	-4.44	0.00
GDP (-2)	-40.07	-16.23	-2.47	0.02
R^2	59.25%	R^2_{adj}	54.96%	

Table 1: The VAR model for Singapore

Table 2 shows the VAR(3) model for the port of Shanghai. The container throughput of Shanghai can be predicted by its lag 1, 2, and 3 data because the related coefficients are significant. Although the data of GDP have no significant impact on the behaviour of container throughput, the VAR(3) model achieves excellent overall fit.

Independent variable	Coefficient	Standard error	*t*-value	*p*-value
Intercept	44725.28	-36914.70	1.21	0.25
THROUGHPUT (-1)	-0.75	-0.23	-3.30	0.01
THROUGHPUT (-2)	-1.30	-0.28	-4.60	0.00
THROUGHPUT (-3)	-0.85	-0.29	-2.92	0.01
GDP (-1)	-0.07	-0.06	-1.24	0.24
GDP (-2)	0.00	-0.05	-0.08	0.94
GDP (-3)	-0.07	-0.07	-1.06	0.31
R^2	93.07%	R^2_{adj}	89.30%	

Table 2: The VAR model for Shanghai

The VAR model for Hong Kong is shown in Table 3. The optimal lag length of model is 5-quarter. Although the estimated coefficients of all throughput variables are statistically insignificant, the lag 4 and lag 5 data of GDP have significant impacts on the process of container throughput. Hence, it implies that GDP is a leading indicator for the data of container throughput in Hong Kong. Meanwhile, VAR(5) model for Hong Kong has excellent goodness of fit according to its values of R^2 and R^2_{adj}.

Independent variable	Coefficient	Standard error	*t*-value	*p*-value
Intercept	114119.60	-31636.70	3.61	0.00
THROUGHPUT (-1)	0.07	-0.15	0.44	0.66
THROUGHPUT (-2)	-0.64	-0.15	-4.15	0.66
THROUGHPUT (-3)	-0.01	-0.17	-0.03	0.98
THROUGHPUT (-4)	-0.05	-0.16	-0.31	0.76
THROUGHPUT (-5)	-0.03	-0.16	-0.18	0.86
GDP (-1)	3.86	-2.78	1.39	0.18
GDP (-2)	0.05	-2.43	0.02	0.98
GDP (-3)	-3.12	-2.25	-1.39	0.18

GDP (-4)	5.63	-2.27	2.48	0.02
GDP (-5)	-13.30	-2.62	-5.08	0.00
R^2	91.52%	R^2_{adj}	88.70%	

Table 3: The VAR model for Hong Kong

The coefficient estimates of VAR model for the port of Shenzhen is shown in Table 4. Because all of the coefficients regarding GDP are statistically insignificant, the throughput of Shenzhen can be predicted by its lag 1, 2, and 3 data. As the measurements of R^2 and R^2_{adj} exceed 90%, this VAR(3) model provides excellent goodness of fit.

Independent variable	Coefficient	Standard error	*t*-value	*p*-value
Intercept	6621.92	-28145.10	0.24	0.82
THROUGHPUT (-1)	-0.74	-0.19	-3.93	0.00
THROUGHPUT (-2)	-0.92	-0.22	-4.20	0.00
THROUGHPUT (-3)	-0.74	-0.18	-4.21	0.00
GDP (-1)	-0.05	-0.04	-1.21	0.25
GDP (-2)	0.00	-0.06	0.07	0.95
GDP (-3)	0.02	-0.06	0.39	0.70
R^2	97.00%	R^2_{adj}	95.37%	

Table 4: The VAR model for Shenzhen

The coefficient estimates of VAR(4) model for the port of Busan are summarized in Table 5. The throughput of Busan is only significantly affected by the lag 2 data of GDP at the 5% level of significance. All other variables have no significant impacts on the process of container throughput. Besides, the goodness of fit is acceptable as the R^2 is 58.31% and R^2_{adj} is 48.21%

Independent variable	Coefficient	Standard error	*t*-value	*p*-value
Intercept	16804.11	-27678.10	0.61	0.55
THROUGHPUT (-1)	-0.17	-0.17	-1.01	0.32
THROUGHPUT (-2)	0.01	-0.18	0.05	0.96
THROUGHPUT (-3)	-0.11	-0.17	-0.67	0.51
THROUGHPUT (-4)	0.03	-0.17	0.16	0.87
GDP (-1)	0.00	0.00	1.01	0.32
GDP (-2)	0.01	0.00	2.50	0.02
GDP (-3)	0.00	0.00	1.23	0.23
GDP (-4)	0.00	0.00	1.62	0.11
R^2	58.31%	R^2_{adj}	48.21%	

Table 5: The VAR model for Busan
Compared the VAR forecasts with the actual throughput data after year 2005, Table 6 summarizes the analysis results of forecasting accuracy. Our findings show that the MAPE

values of all VAR models are less than 4%, which indicate the reliability of VAR approach for the forecast of container throughputs in East Asia ports.

Container port	MAPE	MSD	MAD
Singapore	1.93%	22583633921.56	117630.77
Shanghai	3.21%	37615706638.00	153284.09
Hong Kong	2.10%	20735510580.05	120617.64
Shenzhen	2.26%	13769769564.29	94556.10
Busan	2.16%	6752695723.04	63731.52

Table 6: Measurements of forecasting accuracy

CONCLUSIONS

According to our findings of VAR approach, GDP is a leading indicator of container throughput for the ports of Singapore, Hong Kong, and Busan. Meanwhile, the container throughput of Singapore, Shanghai, and Shenzhen is significantly affected by its lag data. From the perspective of goodness of fit, our VAR models generally provide acceptable results. Meanwhile, measurements of MAPE for VAR models also indicate good capability of forecast. Comparing to other approaches like regression models or grey models, this study provides an alternative method with dependable predictions but requires less model assumptions. Port authority can easily apply our proposed approach to allocate sufficient port facilities for the upcoming demands. Future research may apply VAR models for the other container ports to evaluate its extended practicability. To enhance the prediction accuracy, future studies can develop advanced econometric models and evaluate which models best describe the behaviours of container throughputs.

REFERENCES

Akaike, H. (1973) "Information Theory and Extension of the Maximum Likelihood Principle", Proceedings of the secondinternational symposium on information theory, Budapest, Akademiai Kiad.

Chen, S.-H. & Chen, J.-N. (2010) "Forecasting Container Throughputs at Ports Using Genetic Programming", Expert Systems with Applications, 37, PP.2054-2058.

Chou, C.C., Chu, C.W., & Liang, G.S. (2008) "A Modified Regression Model for Forecasting the Volumes of Taiwan's Import Containers", Mathematical and Computer Modelling, 47, PP.797-807.

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(386), pp.427-431.

Guo, Z., Song, X. & Ye, J. (2005) "A Verhulst Model on Time Series Error Corrected for Port Throughput Forecasting", Journal of the Eastern Asia Society for Transportation Studies, 6, pp.881-891.

Guzhva, V. & Pagiavlas, N. (2004) "US Commercial airline performance after September 11, 2001: decomposing the effect of the terrorist attack from macroeconomic influences", Journal of Air Transport Management, 10, pp.327-332.

Johansen, S. (1988) "Statistical Analysis of Cointegration Vectors", Journal of Economic Dynamics and Control, 12, pp.231-254.

Johansen, S. (1994) "The Role of the Constant and Linear Terms in Cointegration Analysis of Nonstationary Variables", Econometric Review, 13(2), pp.205–229.

Johansen S. & Juselius K. (1990) "Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52(2), pp.169-210.

Lam, W.H.K., Ng, P.L.P., Seabrooke, W. & Hui, E.C.M. (2004) "Forecasts and Reliability Analysis of Port Cargo Throughput in Hong Kong", Journal of Urban Planning and Development, 130(3), pp.133-144.
Lütkepohl, H. (2005) "New Introduction to Multiple Time Series Analysis", Springer.
Marcucci, J. & Quagliariello, M. (2008) "Is bank portfolio riskiness procyclical? Evidence from Italy using a vector autoregression", Journal of International Financial Markets, Institutions & Money, 18, pp.46-63.
Osterwald-Lenum, M. (1992) "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics", Oxford Bulletin of Economics and Statistics, 54, pp.461-472.
Seabrooke, W., Hui, E.C.M., & Lam, W.H.K. (2003) "Forecasting Cargo Growth and Regional Role of the Port of Hong Kong", Cities, 20(1), pp.51-64.
Veenstra, A.W. & Haralambides, H.E. (2001) "Multivariate Autoregressive Models for Forecasting Seaborne Trade Flows", Transportation Research Part E, 37, pp.311-319.

ACHIEVING COMPETITIVENESS THROUGH "LEAGILE" INTERMODAL TRANSPORT SYSTEMS

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I. INTRODUCTION

Leanness and agility concepts have been introduced as important strategies in the production planning and they were considered as the emerging concepts that needs to be considered in the management of strategic supply chain management. Although a considerable literature focused on different aspects of lean, agile and sometimes hybrid versions such as "leagile" strategies, the role of these strategies in the transportation management and logistics industry have not been discussed. Numerous studies have demonstrated the benefits of lean and agile strategies in enhancing the competitiveness of firms but none has really discussed the role of integrated transport systems such as intermodal transport as a way of achieving advanced transport solutions by the use of these strategies. Recently there has been an emerging trend in intermodal transport concept and its different applications in terms of countries, regions and industries exist. Although there is a considerable research on intermodal transport based on various approaches, disciplines and countries, it also shows that there is scant literature and research on the evaluation of intermodal transportation system from the view point of leanness and agility concepts. This study investigates a specific intermodal transport cost model together with the different transport modes within this system according to the ownership, leanness, agility aspects and also each leg in the cost model is considered in terms of its services as having scheduled or non-scheduled characteristics. In accordance with the requirements of the model discussed in the study, each different transport mode is classified under lean, agile or "leagile" categories. Moreover, a conceptual model called "leagile" and competitive intermodal transport system is suggested which includes different variables to be considered for an integrated, customer-focused and competitive transport system. This suggested model is considered as a preliminary conceptual model and a scale can be developed to be applied to mainly logistics service providers and freight forwarders in the logistics industry in order to understand their perceptions as a further research.

II. LITERATURE REVIEW

Global sourcing policies of companies, just-in time inventory control and changing demand from the customers of transport service providers have all had an effect on the emergence of new transportation systems such as intermodal transport, which involves the use of more than one mode to form an integrated transport chain in an environmentally sustainable manner. Due to its characteristics such as the integration and the involvement of different parties and disciplines, the research related to the intermodal transport is considered to be diversified. Apart from traditional intermodal transport research mostly based on the competition among transport modes, actors in the intermodal transport chain and terminal efficiency; this paper discusses the application of "leagility" concept in the intermodal transport operations. Whilst there is a growing recognition of supply chain strategies of leanness and agility in the literature, there is still limited research into the investigation of transportation systems and intermodality especially related to these strategies.

Leanness and agility concepts are suggested as important supply chain strategies by eliminating all waste (leanness) and being responsive and flexible in the market place (agility) **(Christopher et al., 2006). From the view point of manufacturing and supply chain strategies,** Christopher (2000) suggested that lean concepts are appropriate where demand is relatively stable and predictable. Application of agility which requires responsiveness and flexibility can be suggested where demand is volatile and the customer requirement for variety is high. Christopher and Towill (2000) by referring to the market qualifiers and market winners concepts highlighted that leanness is the most powerful paradigm when the winning criterion is the cost. On the other hand, service-related issues, availability and customer-focused philosophy take place in the agile operations. It has been mentioned that the two approaches can overlap with each other and a “hybrid” lean/agile strategy can be adopted. In case of this hyrid solution, while lean approach can be utilised for predictable standard products, agile principles work well with unpredictable or ‘special’ products (Naylor et al. 1999). Base and surge demand play an important role in determining which supply chain strategy to use depending on the market environment and product types (Mangan et al., 2008). The main difference between these demand types is that while base demand is more predictable and less risky where leannness works well, surge demand is more appropriate for agile approaches (Christopher et al, 2006). Considering base and surge demand as the starting point, three main types of transport flows were adapted from Gattorna and Walters (1996). As seen in Figure 1, base flow represents unimodal transport operations with less risk and more predictability since there is minimum transfer of goods and less loss/damage to the cargoes. The type of cargoes in this category are mostly bulk in nature and the transport of these cargoes are based on contract terms such as charter parties. The level of risk and unpredictability increases as the number of transport mode(s) utilised in the transportation system increase due to relatively more possibility of loss/damage, changing customer requirements and rapidly changing factors in the business environment.

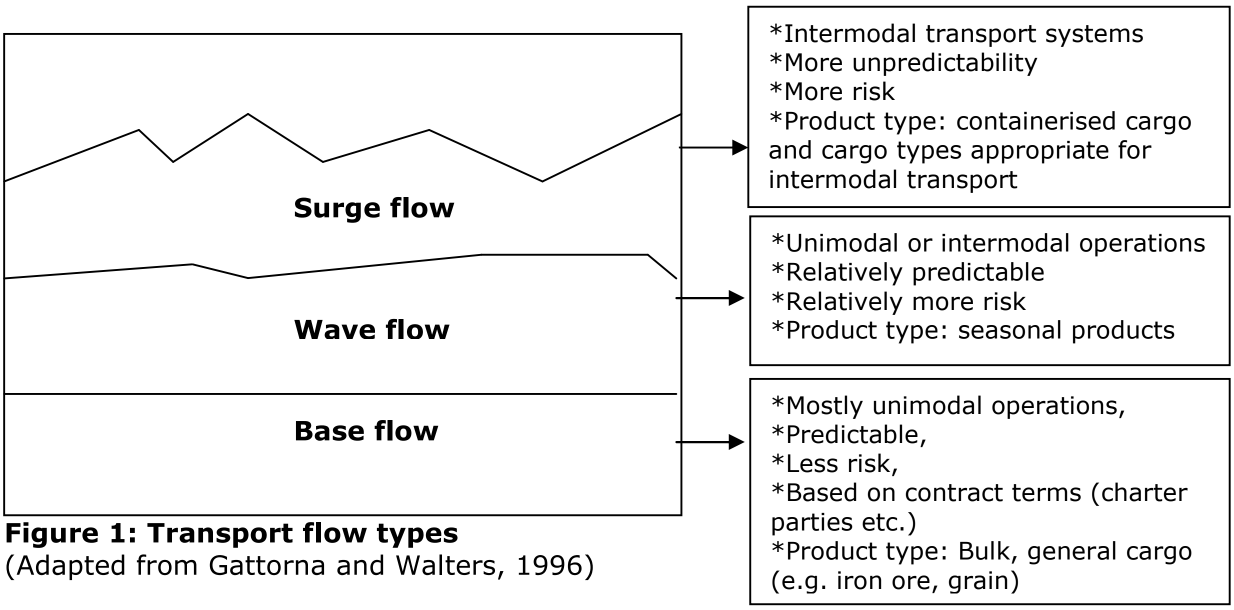


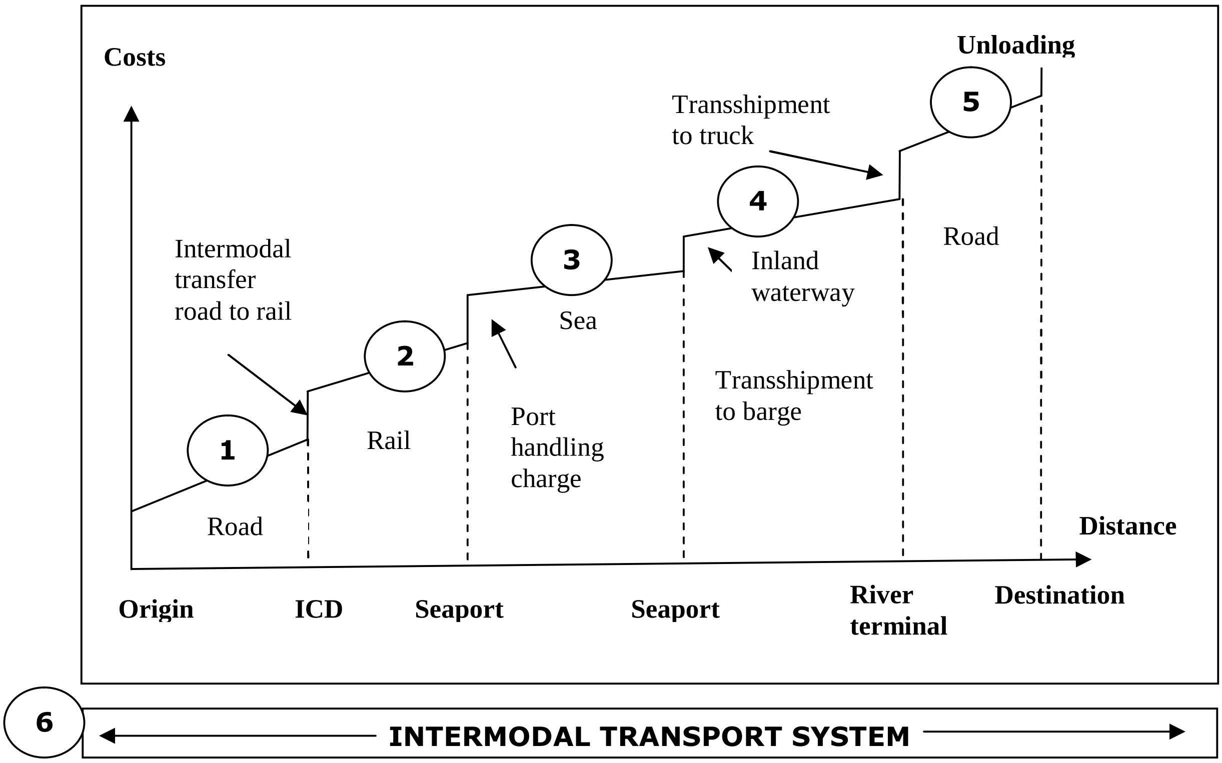
Figure 1: Transport flow types
(Adapted from Gattorna and Walters, 1996)

The second flow type is the wave flow with relatively more risk and lower predictability. The main cargo groups in this flow are mostly seasonal products such as flowers, plants etc. Transport flows of seasonal products are conducted in a certain period of time and this makes the transportation process and volumes to be transported relatively predictable. However, more risk is observed due to the nature of the cargoes which are mostly perishable and/or sensitive. These types of cargoes can be transported by either unimodal or intermodal operations (Beresford et al., 2006). Surge flows mainly experience considerable increases and decreases due to the nature of the cargoes, risk and unpredictability issues. Although containerised cargo mainly has a certain share in maritime transport and liner shipping market aims to provide end-to-end services at acceptable time, quality and cost levels, the demand for the transport of containers by more than one mode of transport mode may fluctuate depending on many different factors. Customer expectations and specific needs of the customers play an important role in determining the scope and the legs of the intermodal transport operations. Tailor-made solutions in terms of specific cargo requirements, different origin and destinations and cost effective operations enable the buyers of intermodal transport services to choose from wide range of transport opportunities. In the light of the identification of transport flow types mentioned above, intermodal transport could be considered more appropriate for agile approach since the market environment as well as the demand for intermodal transport services can be more volatile and unpredictable. However, main requirements of leanness such as cost-focused approach and elimination of waste can be evaluated as main parameters for a competitive intermodal transport chain. Moreover, each single stage of the intermodal transport chain (e.g. road transport from manufacturers' premises to port or handling and transfer operations taking place at ports) can be evaluated by considering the agility and leanness characteristics. Also some stages in the intermodal transport system can be categorised as "leagile" so that an overall evaluation of the consecutive stages in the intermodal system can be discussed.

III. LEAN AND AGILE PARADIGMS AND INTERMODAL TRANSPORT

In this study, an integrated cost model for intermodal transport will be discussed as a starting point by evaluating each different stage in the intermodal transport system according to leanness, agility, leagility and ownership parameters. The intermodal transport cost model, can be considered as a recent cost model with the components of cost (road, rail, waterway, sea, air), time, distance, transport modes, and intermodal transfers (ports, rail freight terminals, ICD) (Beresford, 1999). The main assumptions of the Beresford cost model are based on the premise that unit costs of transport vary between modes and the steepness of the cost curves highlight that for volume movements, sea transport should be the cheapest per tonne-km, road transport should normally be the most expensive (at least over a certain distance), and waterway and rail costs should be intermediate. The model has many applications with different origin and destination points such as transport of whisky from Scotland to Greece, garments from Lao PDR to EU, flowers from Taiwan to China (Beresford et al., 2006). Figure 2 shows the intermodal cost model, the main stages in the possible intermodal transport chain and the classification of each mode within the model in terms of leanness, agility and ownership concepts.

Road transportation has many advantages that it is a mode which can be used in most forms of intermodal transportation. It provides a high degree of accessibility when compared to other modes because trucks can easily go to shipper's premises, pick up the cargo and deliver it to ship, airport or railway terminal (Ballou, 1999; Gubbins, 2003). There is a demand for fast and punctual physical distribution of urgently-required materials in small quantities, a trend which favours road transport. Road transport services can be scheduled or unscheduled depending on the operation and the cargoes to be transported. In the RO-RO transportation example, RO-RO ships mostly use certain ports of arrival and departure, so that the trucks or trailers loaded on these ships follow the same scheduled structure in their operations. In terms of ownership, the main proportion of the transport companies providing road transportation services are private enterprises and fierce competition is experienced in the road transportation industry.



	1	2	3	4	5	6
Scheduled/ unscheduled	Unscheduled/ scheduled	Unscheduled/ scheduled	Mostly Scheduled	Mostly Scheduled	Unscheduled/ scheduled	Mostly Scheduled
Ownership	Mostly Private	Public/ Private	Mostly Private	Mostly Private	Mostly Private	Private
Lean versus Agile	Agile	Lean	Agile	Agile	Agile	LEAGILE

Figure 2: Lean/Agile and "Leagile" Classification of the Intermodal Transport
(Source: Authors)

Road transport can be categorised as agile due to its characteristics that it is a flexible mode with small units of movement and has access to road network enabling it to provide door-to-door transport. Also, control over road transport is easier that each individual truck is managed by one person that the driver can react quickly to any changes during the journey. These characteristics lead to agility concept that requires high degree of flexibility and adaptability. The main reason that road transport cannot purely be considered as lean is that there are some weaknesses of road transport such as increasing pollution, accidents and related social costs, such as traffic congestion in and between urban areas. Since these can be considered as waste in the transportation system, road transport has a tendency to be suggested as agile rather than lean. The second stage in the model is the use of railways that the most of the railway services are scheduled and especially when the use of railways within the intermodal transport system is considered, private railway companies run scheduled services in the transportation of containerised cargo. However, it should be noted that the transportation of bulk cargoes such as scrap iron, grain etc. by railways can be unscheduled due to the production of companies, demand issues or the frequency of railway services in the country. While railway transportation services are privatised in some countries like United Kingdom, state institutions may also provide transportation services to the users of railway services in some countries such as Turkey. Rail transport offers relatively higher fixed costs due to construction and building costs of railways and design of railway networks on a determined mode. On the other hand, they provide relatively low variable costs. Loading, unloading, billing and collecting, yard switching of multiple-product, multiple shipment trains contribute to high terminal costs for rail. Increased per-shipment volume and its effect on reducing terminal costs result in some substantial economies of scale, that is lower per-unit costs for increased per-shipment volume (Hayuth, 1987; Ballou, 1999). Railway transport services can be categorised as lean since they aim to minimise the negative effects of road transport especially in terms of environmental concerns. Gubbins (2003) added as one of the weaknesses of railways the flexibility problem that it is mostly impossible for railways to adapt their infrastructure to meet the changing patterns of economic and social activities. The industry's labor intensive and heavily unionised structure also creates some problems and delays in providing service. These weaknesses do not meet the requirements of agile strategies and prevent railways to offer more flexible transport solutions to its users. Also railways are mostly needed to be connected to road transport for the final leg of the transportation and this makes the railways more restricted in service aspects.

The next leg in the intermodal cost model system is the sea transport. With the invention of containers and increasing use of container shipping, easy and rapid movement ability of cargoes became apparent and this has directed transport service users and providers to an action that more than one mode of transport can be utilised in order to provide a better service in terms of dynamic transportation systems and more environment-friendly transport which is road minimising and sea and rail maximising. When the container transport is the case, more scheduled liner shipping services can be considered and also in voyage charter agreements in bulk shipping, some ports and cargo types are fixed and the services can be scheduled. When sea transport is the case, ports play an important role that the introduction of integrated transport systems and intermodal transport technologies have necessitated the need for restructuring of port infrastructural and superstructural facilities. Advanced handling equipment, integration of rail transport with ports, increasing role of ports as logistics centres and distriparks in some regions of the world and highly growing container trade in all over the world, have required the ports to adapt the changing environment. Sea transportation can be considered as a truly agile system with different aspects such as political/legal, economic, technological, social, natural environment factors. Conventions such as MARPOL, STCW etc. and different regulations related to the safety issues at sea, developments in shipbuilding industry, increasing awareness regarding the environmental issues for sea pollution, advanced security measures at ships and ports especially after 11/9 make the shipping industry more dynamic and more subject to changes. Moreover, meeting the expectations of the customers, informing the customers about the position and the condition of the cargo by the use of track and trace systems, increasing the customer satisfaction in terms of on time delivery of cargoes and providing reliable services especially in liner shipping industry direct the shipping companies to be more agile and responsive. As an important element of sea transportation, ports can also be suggested as agile organisations. As seen in Figure 2, the time spent at ports as interchange points plays an important role in the efficiency of an overall intermodal transport system as well as the overall cost and any delays at ports increase the transit time for the cargoes. Ports act as the connection points between sea and land transport and different types of vehicles and loading units go through series of operations at ports that determine the level of cost and service efficiency. Paixao and Marlow (2003) suggested that ports should be considered within the agile framework since lean theory prevents ports from developing the extra flexibility. They added that lean approach is unable to meet unanticipated customer requirements by being unable to adapt quickly the changes in the port environment. In case of a container port environment, organisational and financial structures of the terminals, the provision of value-added services at ports, intermodal links with the hinterland of the port and the efficiency of handling equipment have an impact on the agility performance of the port. Since port industry as well as shipping industry is open to any kind of change and uncertainty as discussed above, application of lean strategies may not provide expected outcomes and the parties in the port industry such as liner shipping companies, stevedores, terminal operators etc. may experience difficulties in dealing with such an environment.

Following the transport of cargoes/containers by sea transport, inland waterways can be utilised as the next leg in the intermodal system. The inland waterways form a dense network in North-West Europe where waterway transport is essential to the competitiveness of some sea ports with considerable advantages of cost-efficiency, congestion-free and reliable services, reduced emissions, savings on non-renewable energy and adaptability to intermodal transport. Having a similar operational structure and environment with sea transport, inland waterways may also be considered as agile rather than lean. However, the environment friendly character of the inland waterways which reduces emissions and congestion as a form of waste in the intermodal transportation system show some similarities with the lean approach. Since the final leg of the most intermodal transport systems is the road transport in order to achieve flexible door-to-door delivery, road transport is shown as the last stage in Figure 2. Following the evaluation of each leg within the intermodal transport system, the next section will provide a conceptual model of leagile intermodal transport system by integrating the main requirements of leanness and agility.

III. LEAGILE INTERMODAL TRANSPORT SYSTEM

Each intermodal transport system or operation should be considered different in its own since it is increasingly accepted that "one size does not fit all" (Shewchuck, 1998) when it comes to design intermodal transport operations with a wide range of commodity groups wih different origin and destination points. However, common requirements for a competitive and market-oriented intermodal transport operation can be mentioned in order to understand the critical success factors within the transport chain. In the light of base and surge demand approaches, leanness and agility concepts can be considered as the two important parameters and the combination of these are used as the main determinants for a "leagile" intermodal transport system (See Figure 3). The conceptual model is divided into four main parts as agility and leanness determinants, product-related and origin/destination-related influencers and decision-making influencers. When the agility part of the "leagile" intermodal transport system is considered, four determinants as integration, IT systems, collaboration/network approach and customisation can be listed. The basis of intermodal transportation is in the development of systems that integrate the various characteristics of the five modes of transportation. ***Integration*** can be used in three main areas of the intermodal transportation system, namely integration of operational functions, transport modes and administrative flows and liabilities of each parties involved. Intermodal technologies include physical movement and terminal handling technologies as well as the ***information and communication technologies*** required for coordination. Cargo handling technologies, communication and information links are important tools that can be used for bridging the gaps in intermodal transport. Vehicle and cargo tracking technologies such as Global Positioning System (GPS) enable any delays or problems to be monitored and provide feedback about the location of the cargo and the vehicle. ***Collaboration*** between the different actors within the intermodal transport enables the coordinated and effective flow of cargo and information. Extensive information exchange and sharing and close collaboration creates flexible operating systems that are characterised by coordinated operations and they provide shorter channel cycle times and inventory levels. As another important determinant of agility, ***customisation*** is another determinant that intermodal transport operations can be created or modified in accordance with the expectations or requirements of the customers such as the modes and intermodal terminals to be used etc.

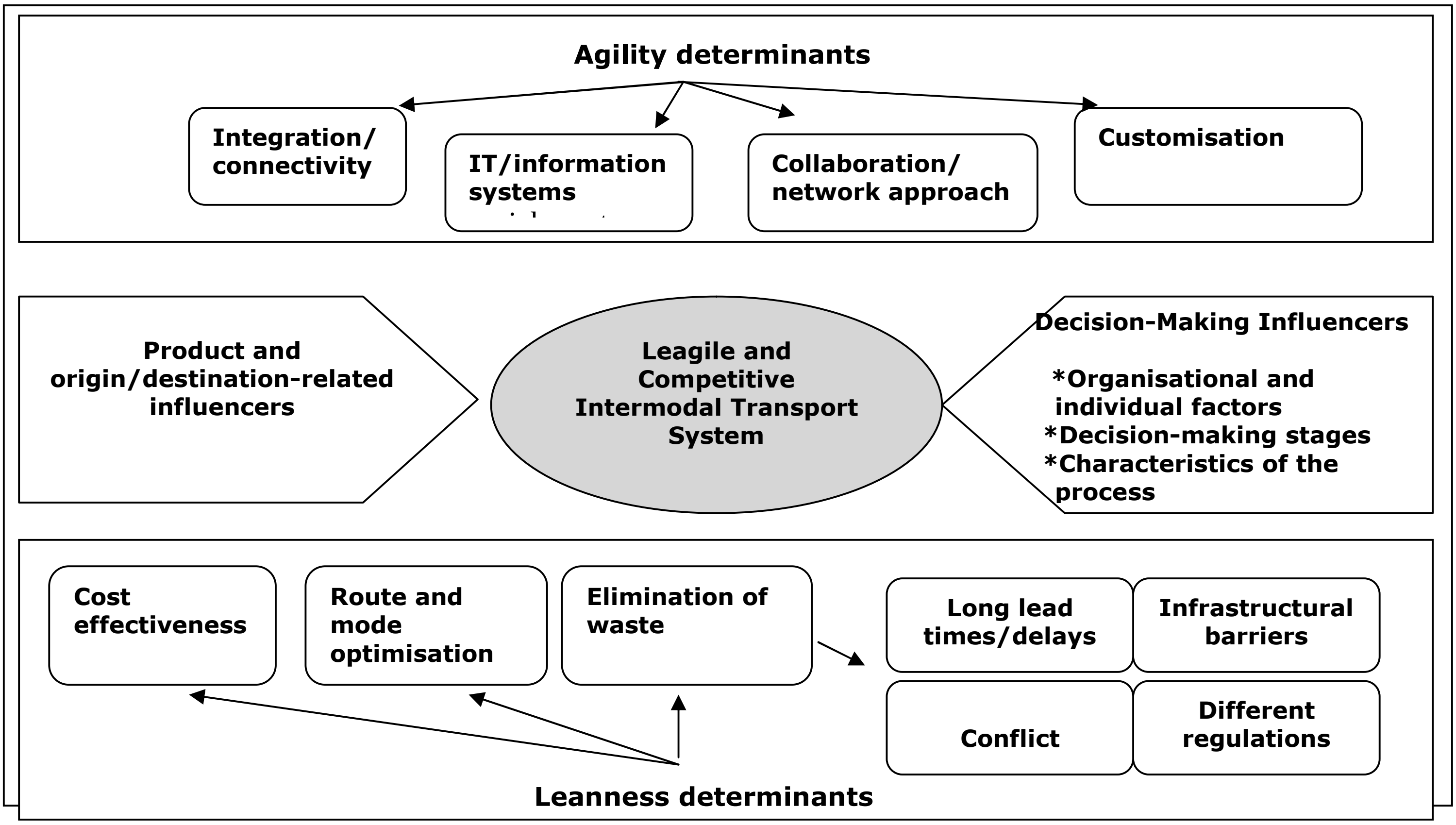


Figure 3: Leagile and Competitive Intermodal Transport System
(Source: Authors)

Cost effectiveness is one of the most important determinants of lean approach and when intermodal transport is the case, successful integration of different transport modes as well as reliable delivery times should also meet the expectations regarding cost issues. In a Delphi study conducted by Denktas Sakar and Marlow (2009), there was no consensus on the existence of high costs about intermodal transport so that in the revised statement almost all the experts mentioned that if the company which provides intermodal transport services (often logistics and freight forwarder companies) to its customers is experienced and professional, there may not be any problem related to high costs because the parties choose intermodal transport when it offers low cost solutions. As discussed in the previous section, ***route and mode optimisation*** provides many advantages in terms of cost, distance, time and efficiency in interchange points. Since ***elimination of waste*** is a major principle in lean approach, it should be considered in terms of intermodal transport in four ways as elimination of long lead times and delays in interchange points such as intermodal terminals, ports or inland container depots (ICD), elimination of any infrastructural barriers such as poor port-railway connections, unreliable railway transport services etc, elimination of different regulations existing for each transport mode and providing standard applications for an overall intermodal transport and finally elimination of conflict issues since marketing channels theory points out that channel conflict can occur because the various participants have different objectives or goals (Taylor and Jackson, 2000). Since the structure of distribution channel of intermodal transport services is quite complex with many functions and many actors, conflict is likely to occur. Apart from agility and leanness determinants, two independent variables such as ***product and origin/destination-related influencers*** and ***decision-making influencers*** can be addded to the conceptual model. Denktas Sakar and Marlow (2009) investigated the impact of these influencers from the view point of intermodal transport and their role in creating a "leagile" and competitive intermodal transport system can be investigated and discussed in a further study.

IV. CONCLUSION

This paper provides a background to the investigation of transport modes in terms of lean and agile concepts and suggests that intermodal transport system can be perceived as a "leagile" solution to the users of these services in the logistics industry. Rapidly changing competitive environment and the increasing expectations of the customers in the transport industry necessitate the application of both lean and agile strategies. The study is original in many ways since it provides an evaluation of leanness and agility concepts from the view point of intermodal transport first time in the literature and discusses the application of a specific cost model according to the main parameters such as ownership, leanness, agility and having scheduled/non-secheduled services as well. Also a conceptual model for a competitive and leagile intermodal transport system is suggested which can be supported with indepth interviews and focus group studies for further research in order to obtain the views of the transport and logistics industry experts and shippers. Apart from qualitative studies, a scale can be developed to test the conceptual model as a survey research to be applied to logistics service providers, freight forwarders and/or shippers. This may enable to understand to which extent the users and buyers of intermodal transport services give importance to the each determinant in their decisions from the view point of lean and agile strategies.

REFERENCES

- Ballou, R. (1999) Business Logistics Management-Planning, Organizing and Controlling the Supply Chain. New Jersey: Prentice Hall
- Beresford,A.(1999)"Modelling freight transport costs:a case study of the UK-Greece Corridor",*International Journal of Logistics:Research and Applications,*2(3),pp.229-246.
- Beresford, A., Zheng, C. and Pettit, S. (2006) "Intermodal transport of flowers and plants: a case study of the Taiwan-Mainland China corridor". In: *Proceedings of IAME 2006 Conference*. Melbourne, Australia.
- Christopher, M., Towill, D. (2000) "Supply Chain Migration – From Lean and Functional to Agile and Customised", Supply Chain Management, 5(4), pp.206-213
- Christopher, M., (2000), "The Agile Supply Chain: Competing in Volatile Markets", *Industrial Marketing Management,* 29 (1), pp. 37-44.
- Christopher, M., Peck, H. and Towill, D. (2006) "A Taxonomy for Selecting Global Supply Chain Strategies", International Journal of Logistics Management, 17 (3) pp. 277-287
- Denktas Sakar, G., and Marlow P. (2009) An Organizational Buying Perspective for Multimodal Transport: A Delphi Study for Turkey, IAME 2009 Conference, 24-26 June 2009, Copenhagen, Denmark.
- Gattorna, J. L. Walters, D. W. (1996) Managing the Supply Chain: A Strategic Perspective. London: Macmillan Business.
- Gubbins, E.J. (2003) Managing Transport Operations, London: Kogan Page
- Hayuth Y. (1987) Intermodality: Concept and Practice, London: Lloyd's of London
- Mangan, J., Lalwani, C., Butcher, T. (2008) Global Logistics and Supply Chain Management, London: John Wiley&Sons.
- Naylor, J.B., Naim, M.M. and Berry, D. (1999) "Leagility: Interfacing the Lean and Agile Manufacturing Paradigm in the Total Supply Chain", *International Journal of Production Economics*, 62, pp. 107-118.
- Paixao,A. and Marlow,P.,(2003)"Fourth generation ports:a question of agility?", *International Journal of Physical Distribution and Logistics Management,*33(4),pp.355-376
- Shewchuk, J.P. (1998) "Agile Manufacturing: One Size Does Not Fit All," In: *Proceedings of the IFIP WG 5.7 Conference on Strategic Management of the Manufacturing Value Chain,* Scotland: Kluwer Academic Publishers, pp. 143-150.
- Taylor, J. and Jackson, G. (2000) "Conflict, power and evolution in the intermodal transport industry's channel of distribution", *Transportation Journal*, 39(3), pp. 5-17

THE DETERMINANTS OF CONTAINERIZED GRAIN SHIPPING

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ABSTRACT
For bulk shipping industry, ocean freight and charter hire is increased at a phenomenal speed in the mid 2000s. To reduce shipping cost, grain importers and shippers have begun to employ containers vessels to move their freight. However, this change has caused following problems. (1) The number of available empty containers in major grain exporting ports is very limited, (2) Container terminals operating efficiency in major grain importing ports are deteriorated due to the crowded heavy grain containers in the quayside storage area, (3) As a result of poor ventilation in containers, grain damage ratio is increased for the importers, and (4) Capacity of professional quayside grain silos is underutilized.

To understand how to minimize the negative impacts resulting from shippers demand transition, this study adopts the analytic hierarchy process to pinpoint major factors affecting shippers' transportation mode choice behaviour. In addition, fuzzy theory is used to calculate the degree of satisfaction of grain importers on these two transportation alternatives, namely, bulk shipping and container shipping

As the transportation mode choice is concerned, this research finding reveals overall cost factor is the most important criterion influencing grain importers' decision-making behavior. The top four important sub-criteria are all belonged to the overall cost dimension, namely, the grain market value, inventory holding cost, transport cost and the in-transit inventory cost. In the cargo and quality control dimension, cargo damage ratio is perceived to be the most important sub-criterion. Using fuzzy AHP technique, the authors find the degree of grain importers' overall satisfaction on bulk carriers is better than on container carriers. Furthermore, container carriers are perceived to have better performance than bulk carriers on simply the following three sub-criteria: flexible batch size of cargo shipment, length of transit time, and free time. Understanding sub-criteria influencing grain importers' transportation mode choice behavior, container carriers can improve their performance on these sub-criteria and attract grain importers' patronage to improve the containers flow imbalance across the Pacific Ocean.

KEYWORD: Bulker, Container shipping, Grain, Fuzzy AHP

INTRODUCTION

Increasing globalization and lowering ocean freight help each nation focus on producing commodities of its specialty. With many high quality but low paid labours, Asian nations have manufactured delicate industrial products and sold them to the EU and the USA. The North America owns large arable lands and is suitable to plant the agriculture produces (e.g. grains) with large farming machineries. The harvest grains can then be exported to the Asian nations. The major grains trade in the cross Pacific Ocean route could include soya bean, corn, and wheat. The rapid increase of dry bulker freight between 2002~2008 makes the grain importers and shippers start to ship their grain cargoes by the dry containers. It is estimated the containerization ratio is around 80% in 2008. The grain containers could be used to control the freight cost for grain importers, and the grain cargoes can be transported on a door-to-door basis. It increases the importers' competitiveness because of its door-to-door service ability, its low ocean freight and small parcel size, reducing grain silo storage time, and avoiding high inventory cost occurred by lengthy in-transit time. In short, the total logistics cost of imported grain cargoes can be reduced by using the container shipping service. Historical data reveal only around 50% of containers exported from the Asian to the North America can find backhaul cargoes, many empty containers were trapped in the North America in the 1990s. The development of exported grain cargoes from the U.S.A. to the Asia by containers reduces the cargoes flow imbalance phenomenon across the Pacific Ocean. In addition to Taiwan, many Asian nations, including China, Korea, and Japan have also employed dry containers to import their grain cargoes. There are several pros and cons by using containers to move grain cargoes:

Pros: small batch size, easy to pick up, quality control, and tracking ability.

Cons: limited accessibility of empty containers in the farms, congestion in the container yards, deterioration in cargo loss ratio, low utilization on grain silo.

This research employs the AHP technique to design the questionnaire, and several face-to-face interviews are made to find out the critical factors influencing grain shippers' and importers' mode choice behaviour. Fuzzy technique is also used to measure the degree of performance of bulk carriers and container carriers when the grain cargoes movement is concerned. These two shipping modes' performance on the twelve decision-making sub-criteria is also discussed. Research purposes of this study include the following points: to find the impact of the containerized grain shipping on the dry bulker operators, to understand grain importers' transportation mode choice behaviour, and to review factors that might influence imported grain cargo damage ratio and improve them.

INDUSTRY REVIEW

Scrapped metal, scrap paper, and cotton used to be the major containerized cargoes imported to Taiwan by ocean carriers. However, soybean, corn, wheat, and barley become one of the most important containerized cargoes carried by the ocean carriers from 2006 to 2008. Taiwan is ranked as the ninth major cereal importer, and is the destination for more than 3% of world cereal export (see table 1).

Table 1 Major cereal imported nations and their world market share

Year / Unit：'000 tons	2002	2003	2004	Average 2002-04	Share of world total (%)
Country/Region	Grain				
Japan	26,605	26,537	25,943	26,326	11
EU	19,738	13,654	13,604	15,665	7
Mexico	14,092	13,352	12,977	13,474	6
Korea	13,389	12,925	12,103	12,806	5
Egypt	10,322	8,119	6,815	8,419	4
Brazil	7,809	8,820	6,317	7,649	3
Algeria	8,611	6,901	7,014	7,508	3
Indonesia	7,754	6,971	6,464	7,508	3
Taiwan	***6,576***	***6,599***	***6,361***	***6,512***	***3***
Iran	6,551	5,199	3,985	5,245	2
World average	245,196	232,846	232,193	236,745	100

Source: FAO (2007)，The State of Agricultural Commodity Markets 2006, Food and Agriculture Organization of the United Nations.

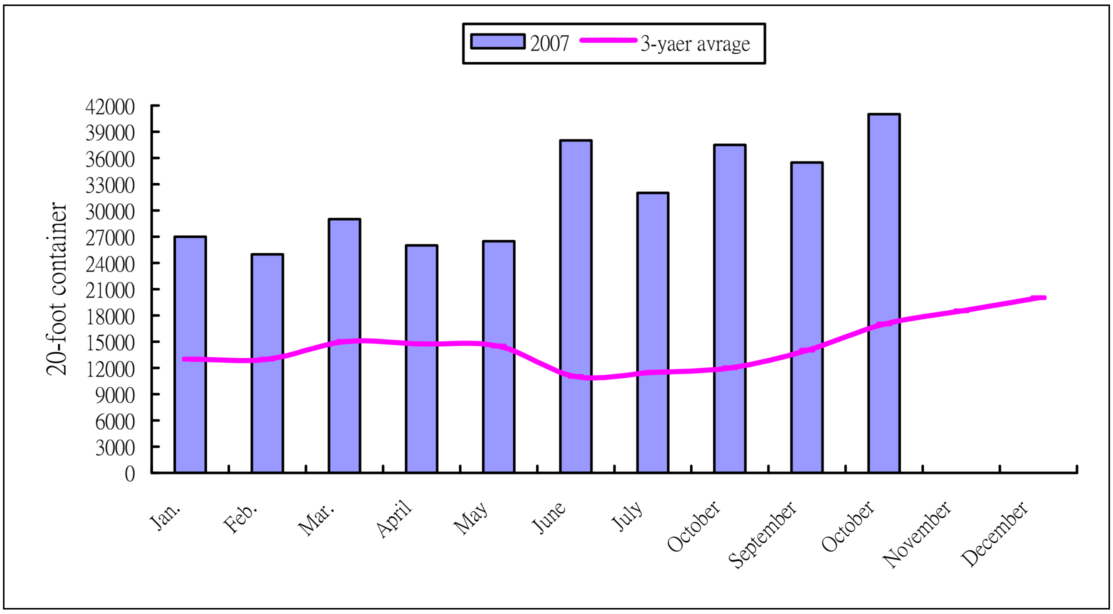
Containerized grain cargoes are not stored in quayside grain silos, thus their volume is not public recorded. Importers can make more income with the information asymmetry advantage to control the retailing grain price in Taiwan. However, the market value and quality of inappropriately stored grains might be decreased if the heavy containerised grain cargoes are idly sit in container yards for several days (see Table 2).

Table 2 Estimate impact of the grain quality on its market price

Grain / Quality	Corn	Soybean
Protein (increase 1%)	Increase USD 2.50/mt	Increase USD 3.00/mt
Fat content (increase 1%)	Increase USD 2.50/mt	Increase USD 2.50/mt
Humidity (increase 1%)	Reduce USD 1.50/mt	Reduce USD 2.80/mt

Note : The humidity of is 12.0%~13.7% for corn and is 11.0%~12.7% for soybean.
Source: Compiled from Soon (2005)

Grains are produced worldwide and their suppliers could be originated in U.S.A., Canada, Australia, Argentina, and E.U. (Lyons, 2000). The top ten cereal importing nations are also evenly situated in different continents (see Table 1). The five American ports, including Seattle, Long Beach, Los Angeles, Tacoma, and Norfolk have exported 69,050 TEUs of containerized grain in 1999 and 2000 (Vachal and Reichert, 2001). According to USDA (2007), there are 3% American export grain cargoes are moved in containers in 2006 (among the 3%, 34% of the cargo is corn. 22% of them are sorghum, and 20% of them are wheat). Comparing with the data in Oct. 2006, the containerized grain cargoes export volume is increased 78% in October 2007 (USDA, 2007).



Source: compiled from American USDA (USDA, 2007) and Port Import Export Reporting Service (PIERS), Journal of Commerce (From Jan. 2007~ October 2007)。

Figure 1 Number of containerized grain cargo export volume (in terms of TEUs).

TRANSPORT MODE CHOICE BEHAVIOUR

There are many literatures studying passenger transportation mode choice, but few literatures focusing on freight transportation mode choice decision-making. In the ocean freight transportation industry, according to the author's knowledge, extant literatures on shippers' and importers' mode choice behaviour are very limited (Meixell & Norbis, 2008; Haugen & Hervik, 2004; Pedersen & Gray, 1998; Evers, Harper & Needham, 1996; Vachal & Reichert, 2001; Pedersen & Gray, 1998; Train & Wison, 2007; Shinghal & Fowkes, 2002; Vannieuwenhuyse et al., 2003; and D'este, 1992; see Table 3.).

RESEARCH METHODOLOGY

This research employs the Analytic Hierarchy Process (AHP) technique and the authors have interviewed major grain importers to find the determinants influencing their transport mode choice behaviour on using the container carriers and bulk carriers to move their grain cargoes. Fuzzy theory is used to calculate the overall performance of the two transport alternatives, fuzzy theory can be used to deal with surveyees' subjective, inaccurate, and ambiguous perception problems in the AHP model.

Table 3 Criteria influencing shippers' decision-making behaviour

Authors / Criteria	Meixell & Norbis (2008)	Pedersen & Gray (1998)	Haugen& Hervik (2004)	Vanneieuwenhuyse et al. (2003)	Evers et al. (1996)	Kent & Parker (1999)	Vachal& Reichert (2001)	Train & Winson (2007)	Shinghal&Fowkes ,2002	D'este (1992)
Transport capacity	✓			✓						
International growth	✓									
Economies of scale & scope	✓		✓							
Cargoes quality	✓							✓		
Environment & energy issues	✓									
Transport cost /Freight rate		✓		✓		✓	✓			✓
Speed		✓		✓						✓
Reliability		✓		✓	✓	✓				
Cargo damage ratio		✓			✓					✓
Flexibility				✓		✓				
Safety & security				✓				✓		✓
Service network density				✓			✓			
Law & regulation				✓						
Inventory cost				✓						
Corporate image				✓						
Tracking ability				✓						
Availability of the transport mode in the origin & destination					✓	✓				
Cargo handling facility					✓	✓				
Compatibility of cargoes & transport vehicles					✓	✓				
Direct transport service					✓					
Service frequency					✓	✓			✓	✓
Cargo batch size					✓					
Easiness of pickup & delivery					✓					
In-transit time					✓	✓		✓		
Inventory holding cost					✓					
Cargo damage claim procedure					✓					
Communication/tracking/control					✓	✓		✓		
After sale service					✓			✓		
Overall service quality					✓			✓		
Distance to the inter-modal facilities							✓			
Seasonal demand factors							✓			

Grain market value							✓			
Dedicated CFS										✓
Free time (demurrage/detention)										✓
B/L release speed										✓
Punctuality & delay record										✓

Source: compiled by this research

AHP TECHNIQUE

AHP technique is a multi-criteria decision making tool, and is used to be applied to improve the decision-making quality under a situation with multiple mutual conflicting goals and decision-making criteria. AHP is firstly proposed by Thomas L. Saaty in 1971 (Saaty, 1980), and this technique is widely applied to solve various decision-making dilemmas. It systemizes and simplifies a complex situation, variables are deconstructed into several hierarchies and variables in the same hierarchy are pairwisely compared to obtain the degree of importance of each variable. Finally the overall performance of each alternative can also be found. Normally there are eight steps in the AHP technique, including, define the research issues, confirm the factors with influencing power, build the hierarchy structure (i.e. goals, objectives, dimensions, sub-criteria, and alternatives) set up the pairwisely comparison matrix, calculate the eigenvalue, examine the consistency index and consistency ratio, and find the priority weight for each alternative and choose the best alternative. There are four advantages to use the AHP technique, including (1) simplify the complex issue by hierarchies, (2) understand and control the decision-making variables, (3) use inaccurate preference measurement, and (4) employ the consistency ratio to examine the degree of agreement among experts. Several drawbacks of the AHP technique are also reported, including imperfect preference transitivity, the scale from 1~9 is confusing, large perception variance between group members, requirements on the independency between variables in the same hierarchy is frequently violated in the real world.

FUZZY THEORY AND LINGUISTIC VARIABLE

Semantic wordings are mostly imprecise and Zadeh firstly proposed the Fuzzy theory in 1965 (Zadeh, 1965). Fuzzy logic is a precise logic of imprecision and approximate reasoning (Zadeh, 2008). If an element cannot be clearly defined its membership to a variable in the set of (0, 1), then Zadeh defined the membership of the element to the variable is between 0 ~ 1, it is a fuzzy set. Membership function, $\mu_A(x)$, can be employed to decide to what extent the variable x is belonged to set A. The fuzzy membership function can be defined as follow: $\mu_A(x) \in (0, 1), x \in X$

Triangular fuzzy set is used to discriminate the degree of membership of a specified semantic wording. Triangular fuzzy set (T) can be define as below (see Figure 2).

T = (l, u, r), and $l \leq u \leq r$, its membership function is defined as below,

$$\mu_A(x) = \begin{cases} \dfrac{x-l}{u-l} & l \leq x \leq u \\ \dfrac{r-x}{r-u} & u \leq x \leq r \\ 0 & \text{other} \end{cases}$$

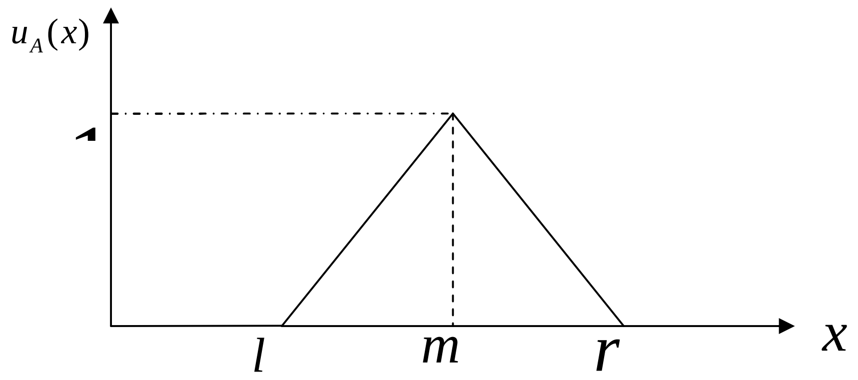


Figure 2 Exhibition of triangular fuzzy function Source: Buckley (1985)

LINGUISTIC VARIABLE

Natural languages are mostly imprecise because in a natural language almost everything is a matter of degree (Zadeh, 2008). Linguistic variable is defined as within a certain limit, a fuzzy set is used to measure the degree of performance given by the natural language, to change the natural language into a logic description and it can then be calculated (Feng & Chiu, 2004). Zadeh (1972) suggests use linguistic variables to process variables that are difficult to be quantified.

This research intends to measure the Taiwan consignees' degree of preference on using the container carriers' and dry bulk carriers' services to ship their imported grain cargoes. Five linguistic wordings are employed in the survey, including very unsatisfactory, unsatisfactory, fair, satisfactory, and very satisfactory. A TFN (triangular fuzzy number) technique is used to define the memberships and values to each of the five linguistic wordings (see Figure 3).

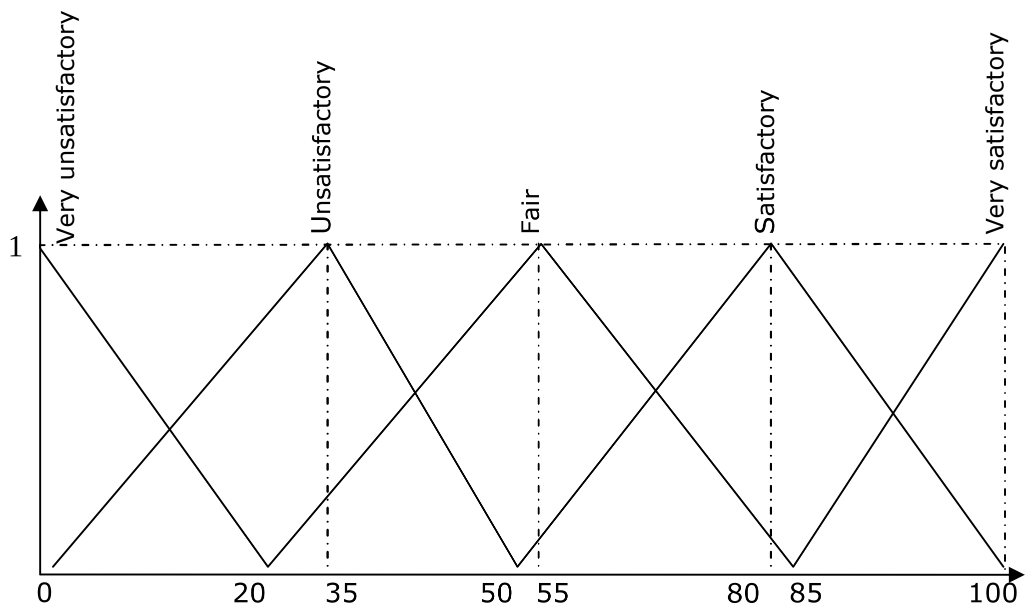


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Figure 3 Five linguistics variables and their membership function from the survey
Source: this research

FUZZY AHP (FAHP) TECHNIQUE

The multi alternatives and multi criteria used to build up the AHP model have different degree of importance and performance to each of the different surveyees (i.e. grain importers). Linguistic variables are used to measure the surveyees' perception on the degree of each alternative's performance on each of the decision-making criterion. Very satisfactory, satisfactory, fair, unsatisfactory, and very unsatisfactory are the five linguistic wordings employed in this research survey, and different TFN is given by each of the surveyees to reveal their subjective judgment on the performance of the two transport alternatives.

Let E_{ij}^{k} be the decision-maker *k*'s perception on the performance of *i* alternative to *j* criterion, j is a criterion in the S set. Then $E_{ij}^{k} = (LE_{ij}^{k}, ME_{ij}^{k}, UE_{ij}^{k}), j \in$ S

As every surveyee's perception on definition of the semantic wordings is different, each of the linguistic wordings has different TFN to each surveyee. Thus geometric mean value of is used to aggregate n surveyees' responses and to represent the n surveyees' aggregated perception. According to Buckley (1985), let E_{ij} represents all decision-makers' degree of satisfaction on *i* alternative's performance in *j* criterion, and E_{ij} is a geometric mean of n respondents' perception (a TFN). Then

$$E_{ij} = \frac{1}{n}(E_{ij}^{1} + E_{ij}^{2} + \ldots + E_{ij}^{N}) = \left(\frac{\sum_{k=1}^{n} LE_{ij}^{k}}{n}, \frac{\sum_{k=1}^{n} ME_{ij}^{k}}{n}, \frac{\sum_{k=1}^{n} UE_{ij}^{k}}{n}\right) = (LE_{ij}, ME_{ij}, UE_{ij})$$

E_{ij} is then used to multiply the degree of importance of *j* criterion found in the AHP model. Then all decision-makers' perception on the weighted performance of *i* alternative on j criterion can be calculated as follow,

$$R_{ij} = E_{ij} * w_j = (LE_{ij} * w_j, ME_{ij} * w_j, UE_{ij} * w_j),\ j \in \text{S}$$

Finally an alternatives' overall performance, R_{ij}, can be represented by a fuzzy set which is an aggregation of R_{ij}, j = 1, 2, …m.

$$R_i = \left(\sum_{j=1}^{m} LE_{ij} * w_j, \sum_{j=1}^{m} ME_{ij} * w_j, \sum_{j=1}^{m} UE_{ij} * w_j\right) = (LR_i, MR_i, UR_i)$$

According to Tsaur et al. (1997), the gravity centre technique can be employed to defuzzify the TFN set by the following formula, and the crispy value of the performance of each alternative can be obtained. Finally the most satisfactory transport alternative perceived by the grain importers can be concluded.

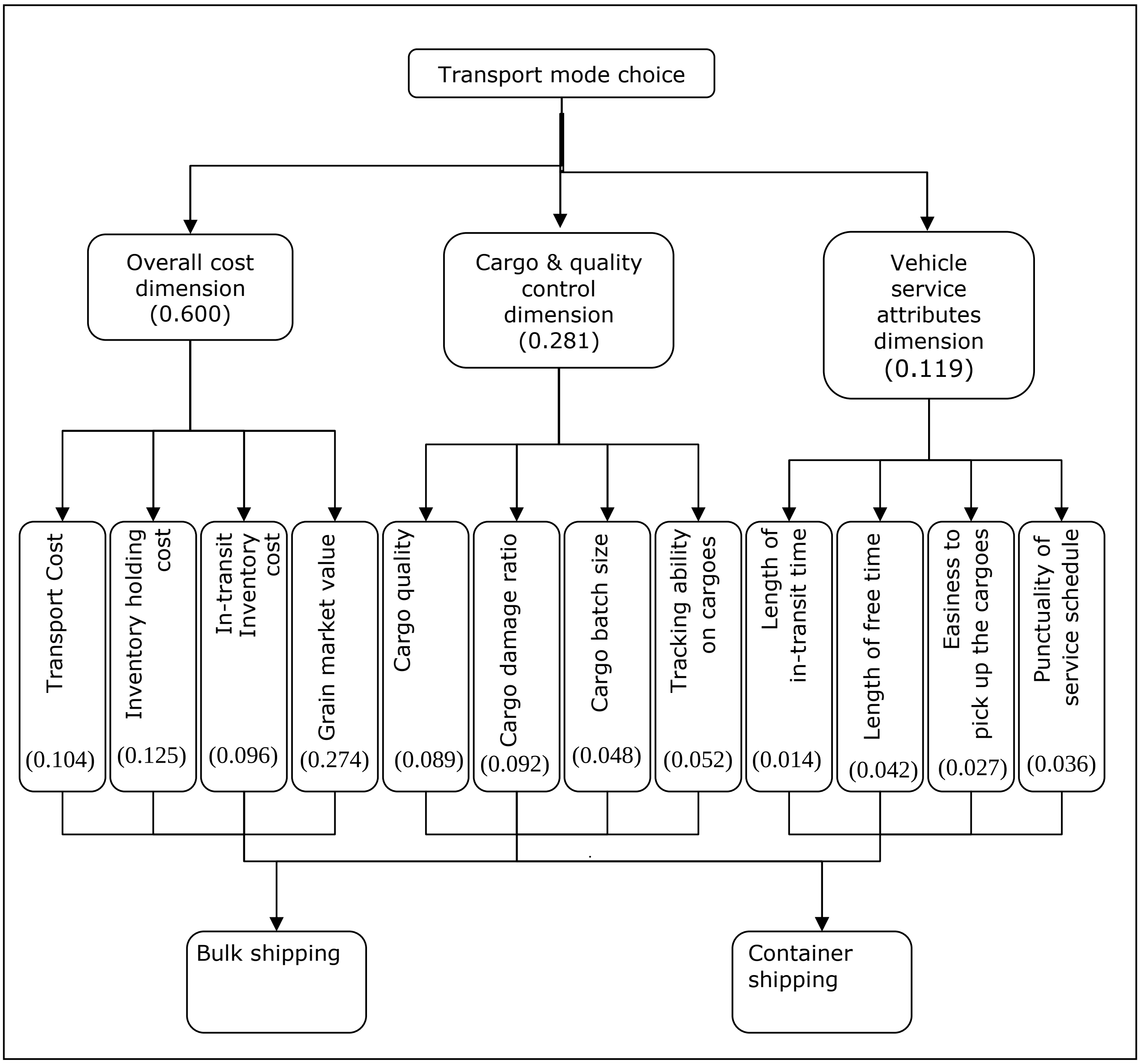
$$BNP_i = \frac{[(UR_i - LR_i) + (MR_i - LR_i)]}{3} + LR_i$$

CRITERIA SELECTION AND SAMPLING

Fourteen criteria are found to be reported at least by three previous reports, and are selected to design the Likert scale questionnaire for the pilot survey in this research (see Table 3). Ninety one copies of questionnaires are dispatched and twenty six copies of them are responded. Criteria with importance less than the mean of the fourteen criteria were removed and twelve criteria are remained to design the AHP questionnaire survey. The twelve criteria are further categorized into three dimensions; namely, cost dimension, cargoes and quality control dimension, and vehicles service attribute dimension (see Figure 4). The AHP round survey is then carried out, followed by several face-to-face in-depth interviews with the grain importers. Finally, the importance and performance of each alternative and each criterion can be found.

RESEARCH FINDINGS

The responded AHP round questionnaires are firstly checked with their consistency ratios and found all responses have their consistency ratios are below the 0.1 threshold value. From Figure 4, overall cost dimension has the highest importance with the importance weight 0.6. This is evidenced by the shippers/consignees employ more containers to move their grain cargoes across the ocean when the BDI was high in 2007. Cargo and quality control dimension has an importance weight of 0.281. The vehicles service attributes dimension has the least degree of importance (0.119). Looking into the importance of each sub-criterion, the 'grain market value' has an importance weight of 0.274, which indicates grain shippers and importers perceive this criterion as the most important factor influencing their freight transport mode choice decision. Other important sub-criteria include the cargo holding cost (0.125), freight transport cost (0.104), in-transit inventory cost (0.096), and cargo damage ratio (0.092).



Source: this research

Figure 4 Hierarchical structure of grain importers' transport mode choice behaviour

In the cargo and quality control dimension, 'cargo damage ratio' is perceived to be the most important sub-criterion. The grain containers are stored in an open area in the container yards before they are loaded on board in the loading port and pick up by the consignees in the discharging port. Grain containers are directly exposed to strong sunshine and heavy rain for a lengthy period, thus the cargo damage ratio could be higher than the grain shipped by a bulker. As the bulker offload the grain into the quayside grain silos with adequate ventilation and humidity control, thus it has a lower cargo damage ratio. In the vehicle service attribute dimension, the 'length of free time' is perceived to be the most important factor. Grain importers could keep their grain containers in the quayside terminals for a lengthy period until the grain market value is high enough for the importers to sell the grains. This long free time practice also leads to the quayside congestion in many container ports in the Far East in 2007 and 2008.

From the grain shippers and importers viewpoint, the performance of the bulkers is higher than the container ships on all the decision-making sub-criteria except the following three sub-criteria, namely, cargo batch size, length of in-transit time, and free time. The grain shippers and importers perceived the two transport modes have the same degree of performance on 'cargo tracking ability' factor (see table 4).

Table 4 TFN and BNP performances of the two transport modes on various criteria

	Bulker's performance		Container carriers' performance		Comparison
TFN & BNP / Criteria/Factors	TFN(R_{ij})	BNP_{ij}	TFN(R_{ij})	BNP_{ij}	Performance between the two modes
Transport cost	(6.136，6.968，7.800)	6.968	(5.2，6.136，7.072)	6.136	B > C
Inventory holding cost	(6.875，8.000，9.000)	7.958	(6.875，7.875，8.875)	7.875	B > C
In-transit inventory cost	(5.088，5.952，6.816)	5.952	(4.992，5.856，6.720)	5.856	B > C
Market price of cargoes	(15.07，17.262，19.728)	17.353	(14.522，16.988，19.454)	16.988	B > C
Commodity characteristics	(5.340，6.141，6.853)	6.111	(4.806，5.607，6.319)	5.577	B > C
Cargo damage ratio	(6.072，6.808，7.544)	6.808	(4.508，5.244，5.98)	5.244	B > C
Cargo batch size	(2.352，2.736，3.168)	2.752	(2.976，3.36，3.744)	3.360	B < C
Tracking ability on cargoes	(2.808，3.276，3.692)	3.259	(2.808，3.276，3.692)	3.259	B = C
In-transit time	(0.770，0.896，1.022)	0.896	(0.784，0.910，1.022)	0.905	B < C
Free time in CY	(1.890，2.352，2.772)	2.338	(2.394，2.772，3.150)	2.772	B < C
Easiness to pick-up cargo	(1.836，2.052，2.295)	2.061	(1.377，1.620，1.836)	1.611	B > C
Punctuality of service schedule	(1.98，2..340，2.664)	2.328	(1.800，2.088，2.412)	2.1	B > C
	R_{bulk}	BNP_{bulk}	R_{con}	BNP_{con}	
Total	(56.217，64.783，73.354)	64.785	(53.042，61.732，70.276)	61.7	B > C

Source: this research

CONCLUSIONS AND SUGGESTIONS

This research has carried out two rounds of questionnaire surveys to measure the freight forwarders, ocean carriers, and grain importers' viewpoints. The performance of the two transport modes on each of the twelve decision-making sub-criteria is measured. The degree of importance of each criterion is also surveyed. The strength and threat factors influencing the grain cargo transport modes choice are then concluded as below.

1. In addition to the variables in the cost dimension, some variables in the cargo and quality control dimension are perceived to have substantial degree of importance. The amount of grains produced in Australia is not as large as the amount produced in the U.S.A. Thus it is not easily to aggregate all the importers' demand and jointly ship the cargo by a dry bulker. The Australian-origin wheat is mostly imported by the container carriers because of its limited trading volume in Taiwan. Importers can shorten the lead time by using container ships and maximize their profit when the domestic market price of the wheat is high.
2. Comparing with dry bulkers, drawbacks of the containerized grain shipping might include worse shipping schedule control, complicated documentation, complex custom clearance and quarantine inspection, and an over-lengthy operation procedure. The container carriers charge higher inland transport freight, cargo handling fee, demurrage fee, inspection fee, custom clearance fee, container cleaning fee, and the other additional charges. Container ocean freight must be $10 USD/ton less than the bulker freight before it can compete with the bulker. Grains moved by containers have to be unloaded in the final destination, mostly a factory. Not all factories have equipped facilities to unload the containerized grains. Grains loaded in containers might have relatively high cargo damage ratio and importers have to deal with the subsequent claiming procedure. The cargo damage risk could easily be shared by the other importers if grains are shipped by a jointly chartered dry bulker. The grain cargoes are only produce in specific seasons, thus containerized grain shipping could result in the uneven containers demand through the whole year.
3. The advantages of containerized grain shipping might include the following points: flexible cargo batch size, easily grading, conspicuous country of origin, and better quality control. Containerized grains are not stored in the quayside silo, the import quantity is kept secretly and thus importers can use the asymmetric information advantage to maximize their profit.

In a stable freight market situation, grain importers perceived the dry bulkers to be the better transport mode than the container vessels. Containerized grain shipping outperforms the dry bulkers only on the following three sub-criteria: cargo batch size, in-transit time, and free time. This might be related with grain shippers' and importers' previous experience of using dry bulkers to move their grains over the last several decades. The relationship between habitual domain and grain importers transport mode choice behaviour could be a possible avenue for the future research.

REFERENCES

1. Buckley, J.J.,(1985), Fuzzy Hierarchical Analysis, Fuzzy Sets and Systems, Vol.17, pp.233-247.
2. D'este G.M. (1992) "Carrier selection in a RO/RO ferry trade Part 2 : Conceptual framework for the decision process", Maritime policy and Management, Vol 19, No2, pp.127-138.
3. Evers, P. T, Harper, D.V., Needham, P.M. (1996) "The determinants of shipper perceptions of modes", Transportation Journal, 36(2), pp. 13-25.
4. FAO (2007) "Most important agricultural imports and exports (in value terms)" accessed http://www.fao.org/statistics/yearbook/vol_1_1/pdf/c10.pdf on 9/28/2008.
5. Feng J.M. & Chiu Y.J. (2004) "Research Methodology", Hsinju city:Chiendu Press.
6. Haugen K. K. & Hervik A. (2004) "A game theoretic "mode-choice" model for freight transportation", The Annals of Regional Science, 38 (3), p469-484.
7. Lyons M. (2000) Diversify Your Wheat Markets, How to Establish Identity Preserved

Channels Using Containers: Wheat Markets in Asia. Spokane. W.A.: Washington Wheat Commission, Idaho Wheat Commission, and U.S. Department of Agriculture Conference presentation.

8. Meixell M. J. & Norbis M. (2008) "A review of the transportation mode Choice and carrier selection literature", The International Journal of Logistics Management, Vol. 19 No.2, PP. 183-211
9. Pedersen E. L. & Gray R. (1998) "The transport selection criteria of Norwegian exporters", International Journal of Physical Distribution & Logistics Management, Vol. 28 No.2, PP. 108-120.
10. Saaty, T. L. (1980) "The Analytic Hierarchy Process-Planning, Priority Setting, Resource Allocation", New York: McGraw-Hill.
11. Shinghal N. & Fowkes T. (2002) "Freight mode choice and adaptive stated preferences", Transportation Research Part E, Vol38, PP.367-378.
12. Soon B.N. (2005) The Competitive Position of U.S. Corn and Soybean in Asian Markets：A Customer's Perspective.
13. Train K. & Wilson W. W., (2007) "Spatially generated transportation demands", Railroad Economics Research in Transportation Economics, Vol. 20, PP. 97-118.
14. Tsaur S.H., Tzeng G.H., and Wang K.C. (1997) "Evaluating tourist risks from fuzzy perspectives," Annals of Tourism Research, Vol.24, No.4, pp.796-813.
15. USDA, 2007, Grain Transportation Report, December 27, 2007. Accessed http://www.ams.usda.gov/tmdtsb/grain/2007/12-27-07.pdf on 12/31/2007
16. Vachal K. and Reichert H. (2001), "U.S. Containerized Grain and Oilseed Exports", Industry Profile: Phase I. USDA
17. Vannieuwenhuyse B, Gelders L, & Pintelon L. (2003) "An online decision support system for transportation mode choice", Logistics Information Management,16(2), pp. 125-133.
18. Zadeh, L. (1965), "Fuzzy sets", Information and Control, 8: 338-353.
19. ZADEH, L. A. (1972). A rationale for fuzzy control, J. Dynamic Systems, Measurement and Control 94, Series G, 3-4.
20. Zadeh L.A. (2008) Is there a need for fuzzy logic? Information Sciences, 178 (13), pp. 2751-2779.

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